Africa RISING West Africa Project

2018/2019 Workplan

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The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-in-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment. http://africa-rising.net/

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Outcome 4: Effective partnerships are built with farmers, local communities, and research and development partners in the private and public sectors to ensure delivery and uptake at scale of SI, technologies, innovations and practices.	
Output 4.1: Alliances and effective partnerships developed between farmers, local communities, and research and development agents in the public and private sectors to enable the release, dissemination, and adoption of proven technologies and practices to scale.	Activity 4.1.1: Conduct cost-benefit and gender analysis coupled with other socio-economic analyses to identify and quantify adoption constraints and opportunities for different farmer contexts. Activity 4.1.2: Map and assess relevant stakeholders to establish dialogue for the exploration of mutual synergies for scaling delivery of validated technologies. Activity 4.1.3: Leverage/link and integrate (engagement and outreach) with existent initiatives including Government extension systems to support and encourage the delivery pathways.
Output 4.2: Gender-sensitive decision support tools to assess technology-associated risks and opportunities are available for use by project partners.	Activity 4.2.1: Identify and communicate gender-sensitive decision support tools in the context of different farm typologies.
Output 4.3: An updated framework for monitoring technology adoption to be used by the project team and scaling partners available and accessible	Activity 4.3.1: Monitor and report technologies and their associated beneficiaries or farmers exposed to the innovations using the tools developed by IFPRI. Activity 4.3.2: Make these reports available on the Africa RISING repositories.
Output 4.4: Knowledge sharing centers (physical structures) and learning alliances are developed within existing local and regional institutions	Activity 4.4.1: Establish knowledge-sharing and learning alliances among scaling actors.

Ghana

Partners and their responsibilities

Name	Acronym	Role/responsibility
Government Ministries/Entities		
Ministry of Food and Agriculture	MoFA	Scaling-out SI technologies and establishment of R4D platforms
Ghana Health Services	GHS	Household nutrition R4D with UDS and IITA
Women in Agriculture Development	WIAD	To improve the lives and working conditions of rural households
National Academic/Research Institutions		
Animal Research Institute	ARI	R4D on livestock production (sheep and goats) with ILRI
Kwame Nkrumah University of Science and Technology	KNUST	Graduate student training and R4D on soil-water dynamics
Science and Technology Policy Research Institute	STEPRI	Policy and institutional research
University for Development Studies	UDS	R4D on livestock nutrition and human nutrition, Graduate student training
International Academic/Research Institutions		
International Food Policy Research Institute	IFPRI	Lead site selection, baseline survey and monitoring and evaluation
International Institute of Tropical Agriculture	IITA	Overall project coordination and R4D research on cereal-legumes
International Livestock Research Institute	ILRI	Lead R4D on ruminants in Ghana and natural resources governance in Mali
International Water Management Institute International Center for Tropical Agriculture	IWMI CIAT	Lead R4D on water management Collaboration on soil-water-management
Wageningen University and Research, The Netherlands	WUR	R4D on farming systems characterization and graduate training

Summary

The Africa RISING West Africa (WA) project is being implemented by multi-disciplinary research teams and development partners from the public and private sectors in collaboration with farmers and community-based organizations in northern Ghana and southern Mali.

This document presents the work plans for the 2017 research year for Ghana. The work plans are mapped under the four Outcomes in the Phase 2 project log frame (See Table 1 below). Nine activity protocols are presented – four for Outcome 1; two each for Outcomes 2 and 3; and one for Outcome 4. The nutrition activities are integrated with the livestock and vegetable activities in protocol GH211-17 under Outcome 2 in response to the recommendation of the USAID-commissioned external evaluation team.

Gender mainstreaming, capacity building and knowledge exchange and dissemination are embedded in all activity protocols. Linkages between activities are presented in each activity protocol. Publication of research results and better communication among research teams within and across countries will be a major focus.

Background

Phase 1 (1 October 2012 - 30 September 2016) of the USAID-funded Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) project in West Africa (WA) was implemented in 25 intervention communities in northern Ghana and 9 villages in the Bougouni and Koutialia districts of the Sikasso Region in southern Mali under the *title 'Sustainable Intensification of Key Farming Systems in the Guinea-Sudano-Sahelian Zone of West Africa'*. Research activities under Phase 1 were organized around 3 research outputs (ROs), namely: 1) Situation analysis and program-wide synthesis (RO1); 2) Integrated Systems Improvement (RO2) and 3) Scaling and Delivery (RO3). Capacity building and gender were cross-cutting.

Phase 2 (1 October 2016 - 30 September 2021) of the WA project was launched in February 2017. The workplan is organized around 21 activities under 11 outputs to achieve four outcomes (Table 1). Implementation will be guided by achievements and lessons from Phase 1. There will, however, be a shift in approach from Research-for-Development (R-4-D) in Phase 1, to Research-in-Development (R-in-D) in Phase 2.

Technological packages and/or practices validated in Phase 1 (see Table 2) will be scaled out targeting agro-ecosystems and socio-economic circumstances defined by the sustainable intensification (SI) domains - productive, economic, social, human and environmental. Linkages will be established with research and development partners to undertake both generic and back-stopping research. The generic research aims at completing the loose ends of research on the SI innovations in Phase 2 plus any other emerging issues. The back-stopping research will address researchable issues emerging from the scaling-out of SI innovations with the development partners.

Phase 2 will also explore new research areas emerging from Phase 1 experiences and feedback by research and development partners, notably, using results from farming systems analyses and farm types to inform research targeting and technology dissemination; post-harvest management and value addition; nutrition-sensitive agriculture; labor-saving mechanization solutions for small-scale farmers; and climate-smart agriculture. The project will also develop the following research and development strategy documents: 1) a livestock strategy to increase the impact of livestock-related activities, especially those on small ruminants, poultry and pigs; and a nutrition strategy to harmonize nutrition-related activities with the crop and livestock activities, as well as with national nutrition approaches. It will engage in the purposeful inclusion of gender and youth concerns and develop more rigorous and quantitative approaches for measuring diffusion and early adoption of SI technologies.

This document presents the work plan for Ghana for the 2017 research year. The work plan for Mali for the same period is presented in a separate document.

Table 1: Outcomes, outputs and activities of Africa RISING West Africa project Phase 2	
Outcome 1: Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.	
Output 1.1: Research products for more productive, intensive, diverse, profitable and resilient crop (cereals, legumes, and vegetables); livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities.	Activity 1.1.1: Test a combination of climate-smart crop varieties and agronomic practices to increase and sustain food and feed production. Activity 1.1.2: Test and disseminate a combination of improved breeds, housing, feeding, health and breeding practices to intensify rearing of livestock (sheep, goat, pig, and poultry) for meat, egg and milk production.
Output 1.2: Integrated management practices and innovations to improve and sustain productivity and ecosystems services of the soil, land, water and vegetation resources are developed and disseminated with farmers and development partners in the intervention communities.	Activity 1.2.1: Test and disseminate land, soil and integrated land-soil technologies and practices to improve and sustain productivity and ecosystems services at the farm and landscape/watershed levels. Activity 1.2.2: Test and promote water management technologies and practices to increase water productivity in small-scale crop-livestock farming systems under rainfed and irrigated conditions.
Output 1.3: Labor-saving and gender-sensitive technologies in target areas to reduce drudgery while increasing labor efficiency in the production cycle delivered.	Activity 1.3.3: Demonstrate small-scale maize shelling machines to smallholders and other stakeholders to reduce drudgery and labor requirements
Outcome 2: More farmers and farm families are adopting technologies and practices to improve nutrition, food and feed safety, post-harvest handling and value addition.	
Output 2.1: Improved technologies, innovations, practices and habits to increase production and consumption of safe diverse and more nutritious food for farm families, especially by women and children developed and disseminated in partnership with research and development partners.	Activity 2.1.1: Develop a nutrition strategy to harmonize the nutrition activities national nutrition approaches and link them to the crop and livestock activities Activity 2.1.2: Increase the capacity of farm families, especially women to produce and consume diverse and more nutritious food.
Output 2.2: Postharvest technologies and practices to provide options for the food, and feed sectors are tested and disseminated to farmers, through researchers, extension staff, and development partners.	
Outcome 3: Farmers and other value chain actors have greater and equitable access to production assets and markets (input and output) through enabling institutions and policies.	
Output 3.1: Improved policies and institutional arrangements to increase the participation of farm families, especially women and youth in the output and input markets and decision-making are developed	Activity 3.1.1: Identify constraints to and opportunities for improving access to the output and input markets by women and youth in the target area.

Output 3.2: Options to increase access to production assets and increase participation in decision-making by women, youth and other vulnerable groups.	Activity 3.2.1: Identify constraints to, and opportunities for increasing women and youth access to production assets in the target area.
Outcome 4: Effective partnerships are built with farmers, local communities, and research and development partners in the private and public sectors to ensure delivery and uptake at scale of SI technologies, innovations and practices.	
Output 4.1: Alliances and effective partnerships developed between farmers, local communities, and research and development agents in the public and private sectors to enable the release, dissemination, and adoption of proven technologies and practices to scale.	Activity 4.1.1: Conduct cost-benefit and gender analysis coupled with other socio-economic analyses to identify and quantify adoption constraints and opportunities for different farmer contexts. Activity 4.1.2: Map and assess relevant stakeholders to establish a dialogue for the exploration of mutual synergies for scaling delivery of validated technologies.
Output 4.2: Gender-sensitive decision support tools to assess technology-associated risks and opportunities are available for use by project partners.	Activity 4.2.1: Identify and communicate gender-sensitive decision support tools in the context of different farm typologies.
Output 4.3: A framework for monitoring and evaluating technology adoption, and technology-associated risk accessible to the project team and scaling partners	Activity 4.3.1: Monitor and modify the progress of the technology adoption process towards scaling
Output 4.4: Knowledge sharing centers (physical structures) and learning alliances are developed within existing local and regional institutions	

Table 2: List of validated technologies ready for promotion through development partners in the Northern, Upper East and Upper West regions of Ghana

Broad category	Validated flagship technology
Introduction of new crops and varieties to overcome existing biotic and abiotic stresses and improve productivity per unit land area	New varieties – drought-tolerant maize, rice, aflatoxin resistant groundnut, sorghum hybrids, early-maturing cowpea, dual-purpose cowpea, short-duration soybean, medium soybean, high yielding and disease resistant varieties of vegetables (okra, roselle, tomato, eggplant and pepper)
Agronomic practices to improve grain and fodder yield per unit land area, and improve soil nitrogen	Cereal-legume intercropping Cereal-legume rotations Dual-purpose food legumes Cereal-vegetable intercropping
Integrated soil fertility management as a cost-effective approach to replenish soil fertility	Optimized N and P fertilizer rates Fertilizer micro-dozing Livestock corralling for manure/urine Cereal-legume rotations Cereal-legume intercropping
Improved livestock feeds and feeding, housing, health and breeding management packages	Sheep/goat flock feeding package Sheep/goat health package Housing and feeding for poultry Guinea fowl hatching and brooding management

	Stover quality improvement
Introduction of pre- and post-harvest technologies to reduce food waste and improve food safety	Storage – PICS bags, plastic drums Aflasafe application

Planned work

The planned activities are presented in the protocols. Activities under each protocol are aimed at achieving the outputs under the four outcomes in the project log frame (Table 1).	
2018 Africa RISING West Africa Activity Protocol – Outcome 1: GH111A-18	
Outcome 1: Farmers and farming communities in the project area are practicing more productive, resilient, profitable and sustainably intensified crop-livestock systems linked to markets.	
a. Output 1.1	Research products for more productive, intensive, diverse, profitable and resilient crops (cereals, legumes, vegetables), livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities.
b. Activity 1.1.1	Test a combination of climate-smart crop varieties and agronomic practices to increase and sustain food and feed production
c. Sub-activity GH111A-18	Test, disseminate and adapt crop, livestock and integrated crop-livestock technologies and practices to increase and sustain the productivity of smallholder crop-livestock farming systems

d. Research team

Name	Institution	Role
Abdul Rahman Nurudeen	IITA	Cereal agronomy and plant nutrition
Bekele Kotu	IITA	Economic analysis
Gundula Fischer	IITA	Gender studies
Francis Muthoni	IITA	GIS input
Adda Wesseh	UDS	Livestock nutrition
Fred Kizito	IITA	Land and soil management
Jean-Baptiste Tignegre	WorldVeg	Vegetable breeding
Alpha Sidy Traore	WorldVeg	Field supervision Mali
Daniel Boakaye	WorldVeg	Field supervision Ghana
Legessse Wubetu	WorldVeg	Crop protection
Edoh Kukum	WorldVeg	Post-harvest
Victor Afari Sefa	WorldVeg	Guidance
M. Kabirou N'Diaye	WorldVeg	Guidance
Zenebe Adimassu	IWMI	Water management

e. Student(s)

Name	Institute	Degree	Start	End
Albert Berdjour	UDS	MPhil	2016	2019
Felix Oteng Dwaah	UDS	MPhil	2017	2020
Josuah Kubasri Adda	UDS	MPhil	2017	2020
Abdul Rahman Ayuba	UDS	MPhil	2017	2020

f. Location(s)	Northern (Tingoli, Cheyohi no. 2, Doku, Tibali), Upper East (Samboligo, Nyangua, Gia, Bonia), Upper West (Zanko, Guo, Goli, Goriyiri) regions
g. Start	June 2018
h. End	December 2020
1. Justification	

Small-scale crop-livestock farming systems predominate in the intervention communities of the Africa RISING project in the three northern regions of Ghana. Farmers grow cereals (e.g., maize, rice, millet and sorghum), legumes (e.g. groundnut, cowpea, soybean, Bambara, pigeon pea) and vegetables (roselle, okra, pepper onion, garden egg, tomato, amaranths, pumpkin) in pure or mixed stands. They raise livestock (cattle, sheep, goats, pigs and poultry) under extensive and semi-intensive systems for meat and milk for food, manure for crop production, cash, power for land cultivation and transport, with limited feed, shelter, health care, and breeding management. Total productivity of the integrated crop-livestock systems is generally low, partly due to the weak integration of the crop and livestock enterprises and limited use of good agronomic and animal husbandry practices.

Crop yields on farmers' fields are generally poor due to low and variable rainfall, drought, low and declining soil fertility, use of low yielding varieties, lack of quality seed of improved crop varieties and land preparation equipment, high cost of inputs and postharvest losses, labor constraints that lead to poor growing conditions (late sowing, sub-optimal plant populations, inadequate control of weeds, *Striga*, pests and diseases), and low use of organic or mineral fertilizers. The productivity of the animals is low due to inappropriate husbandry (feeding, health care, housing, and breeding) practices that result in high mortality rates. Farmers have limited access to veterinary services and improved livestock breeds. Fallow land grazing and crop residues are the main feed resources for the livestock. Due to high human and livestock populations, fallow lands are overgrazed leading to degradation of the land, soil and vegetation resources.

In Phase 1, several interventions were tested in partnership with multiple partners including farmers and community-based organizations using the technology park approach. They included: testing and dissemination of improved crop varieties (drought and striga resistant, high yielding, short/medium/long duration multi-purpose crops); appropriate agronomic (planting density, cereal-legume-vegetable intercropping, crop diversification, and agroforestry) and animal husbandry (semi-intensive and intensive management, dry season feed supplementation, vaccination and deworming) practices, and ensuring better integration of the crop and livestock enterprises. Group and individual trainings and short courses were used to strengthen the capacities of the partners. Academic trainees at MSc and PhD levels were engaged to address important knowledge gaps and to build national research capacity. Limited studies were conducted to examine effects of cropping technologies on soils (nutrient depletion) and the interactions among soils, crops and livestock; simulation via crop-processed models to address systems stability and trade-offs, and production variability and risk assessment.

This protocol addresses crop-livestock-vegetable related issues in the Africa RISING West Africa Phase 2 project logframe, especially Activity 1.1.1 (Table 1). The research activities for 2018 within this protocol focus on developing good agronomic practices to maximize the production of food and feed from cereal-legume and vegetable systems. The activities are: 1) variety and planting density effects on grain and fodder yield and quality of groundnut, and 2) leaf stripping to optimize grain and feed from maize-based cropping systems, 3) cowpea living mulch effect on weed control, soil properties and maize yield and 4) intensifying and diversifying rainfed and irrigated vegetable. These research activities were conducted in 2017 and data were collected on productivity and environment domains leaving out economic, social and human domains. A second-year data would be required to validate the 2017 data and to collect data from the other SI domains.

In response to the recommendations of the USAID team to give regional relevance to research activities, technology extrapolation maps would be developed to identify suitable areas for scaling technology within West Africa.

Knowledge transfer and scaling strategies will include: establishment of research-for-development plots to demonstrate technologies; participatory and joint learning approaches for technology testing, e.g., Community-based Technology Parks; development of media materials (posters, leaflets, films) for extension staff, farmers, etc.; organize exchange visits for farmers and researchers; training of trainers and hands-on training for farmers.
Sub-activity GH111A-1801: Variety and planting density effects on grain and fodder yield and quality of groundnut - Leader: Abdul Rahman Nurudeen
Groundnut is the most important food and feed crop in West Africa. Grain and fodder yields are low due to limited use of improved varieties and inappropriate agronomic practices such as low planting densities. Consultations by the Groundnut Scaling and N2Africa projects show that farmers use different planting densities for most of the improved varieties released over the past decade. Secondly, fodder yield and quality were not considered as selection criteria in the breeding programs. Therefore, a study was started in 2017 to test the hypothesis that variety and planting density significantly affect grain and haulm yields and quality and weed population in fields of released groundnut varieties in northern Ghana. This study was started last year, and data were collected in the productivity and environment SI domains leaving out economic, social and human SI domain. However, a second data would be required to confirm the first year's results and to collect data on the other SI domains.
2. Objectives
2.1 Determine the effect of plant density on groundnut yield
2.2 Evaluate adaptability and suitability of improved groundnut varieties to different agro-ecologies
2.3 Evaluate the effect of gender on the yield of groundnut
2.4 Evaluate the effect of groundnut variety and plant density on the quantity and quality of groundnut fodder
2.5 Generate technology extrapolation domains in West Africa
3. Research questions
3.1 How do different plant densities affect yields of groundnut?
3.3 How do improved groundnut varieties adapt to the different agro-ecologies?
3.4 How does gender affect groundnut yield?
3.5 How do feeding residues of different groundnut varieties to small ruminant affect their growth performance?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
The effect of 4 plant spacing (30 x 15, 45 x 15, 60 x 15, 75 x 15 cm) on grain and haulm yield of six groundnut varieties (Chinese, Azivivi, Yenyawoso, Manipinta, Samnut 22, Samnut 23) will be evaluated using a split plot design in the technology parks and on selected farmers' field. A gender survey will be conducted to evaluate male and female preferences. Farmers' field day will be organized. Cost-benefit and labor input analysis for treatments would be estimated. Technology extrapolation domain will be developed to identify suitable areas for scaling out. The haulms will be analyzed for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and in vitro organic matter digestibility (IVOMD). A feeding trial will be conducted on-farm with 6-10 sheep or goats per treatment to determine voluntary intake and growth performance.

5. Data to be collected and uploaded	Responsibility
5.1 Grain and haulm yield	IITA

5.2 Access to labor, timing and frequency of farm operations, decision making at farm level		IITA
5.3 GPS coordinates for all experimental sites		IITA
5.4 Determinants of fodder quality (CP, NDF, ADF), intake, digestibility, growth performance		UDS
6. Milestones		
Deliverables	Means of verification	End date
6.1 Agronomic and gender preference for technology data	Project annual report	Mar. 2019
6.2 Cost-benefit and labor input data	Project annual report	Mar. 2019
6.3 Livestock productivity data	Project annual report	Mar. 2019
6.4 Technology extrapolation domain	Maps	Aug. 2019
6.5. Database on spacing on groundnut	Dataverse	Dec. 2019
6.6. Paper published: Variety and plant spacing effects on groundnut grain and fodder yields	Journal Agronomy for Sustainable Development Animal Feed Science Technology Land use policy	Dec. 2020
7. Sustainable intensification indicators		
7.1 Productivity	Crop and livestock productivity at the plot/ field and farm levels	
7.2 Environmental	Vegetative cover and soil quality at plot/ field level	
7.3 Economic	Profitability and input use efficiency at plot/ field level	
7.4 Social	Gender equity at plot/ field level	
7.5 Human	Food security and nutrition at plot/ field level	

Sub-activity GH111A-1802: Leaf stripping to maximize food and feed yields from maize-based cropping systems - Leader: Abdul Rahman Nurudeen
Feed shortages during the cropping season constrain cattle, sheep, goat and pig production in small-scale crop-livestock systems. The lower leaves of cereals, especially maize can be stripped after tasseling or silking to provide feed during the cropping season without compromising the grain yield. The effect of stripping may vary with the maize maturity type. Quantitative information on such practice in northern Ghana and West Africa is limited. This study was started in the 2017 research year, second-year data is required to confirm the first-year results.
2. Objectives
2.1 Determine the effect of leaf stripping on grain and fodder yield of maize
2.2 Evaluate gender preferences for leaf stripping
2.3 Determine the feed value of stripped maize leaves
3. Research questions
3.1 How does leaf stripping and maize maturity type affect grain and fodder yields?
3.3 What are gender preferences for maize leaf stripping?
3.4 How does the maize maturity type affect the quality of stripped leaves?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
The effect of three levels of maize leaf stripping (no stripping, stripped at 50% tasseling and stripped at 50% silking) and maize maturity type (Extra-early: Abontem; Early, Omankwa; Medium, Obatanpa) on

grain and fodder yields of maize will be determined using a 3 x 3 factorial treatment arrangement in a randomized block design in the community-based technology parks and on selected farmers' fields. A gender survey and farmers' field day will be conducted to evaluate male and female preferences.

The fodder will be analyzed for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and in vitro organic matter digestibility (IVOMD).

5. Data to be collected and uploaded	Responsibility
5.1 Grain and haulm yield	IITA
5.2 Access to labor, timing and frequency of farm operations, decision making at farm level	IITA
5.3 Determinants of fodder quality (CP, NDF, ADF)	UDS

6. Milestones		
Deliverables	Means of verification	Date
6.1 Agronomic data and gender preference for technology data	Project annual report	Dec. 2019
6.2 Gender survey Data	Project annual report	Dec. 2019
6.3. Database on maize leaf stripping	Dataverse	Dec. 2019
6.4. Paper: Leaf stripping effects on maize grain and fodder yields	Experimental Agriculture	Dec. 2020

7. Sustainable intensification indicators	
7.1 Productivity	Crop productivity at the plot/ field and farm level
7.2 Economic	Profitability and input use efficiency at the plot/ field level
7.3 Social	Gender equity at the household level
7.4 Human	Food security at the plot/ field level

Sub-activity GH111A-1803: Cowpea living mulch effect on weed control, soil properties and maize yield - Leader: Abdul Rahman Nurudeen

Maize (*Zea mays* L.) is a major cereal crop in West Africa, accounting for slightly over 20% of the gross domestic producti in the sub-region (Manyong et al., 2000[1]). Grain yields on farmers' fields are low due to several biophysical and socio-economic factors, including low and erratic rainfall, low soil fertility, and weed infestation. Living mulch of legumes conserve nitrogen in grain crops, reduce soil erosion and weed pressure, and increase soil organic matter (Hartwig and Ammon, 2002[2]). This study was planned to start during the 2017 research year to test the hypothesis that cowpea living mulch can significantly improve soil properties, reduce weed infestation, and increase maize yield under the Guinea-Sudano savanna conditions of West Africa. However, it could not be implemented due to the late start of the rains. This study was started last year with data collected in the productivity and environment SI domains leaving out the economic, social and human SI domains. However, the one-year data is not

[1] Manyong V. M., Kling, J G., Makinde K. O., Ajala S. O, Menkir, A., 2000. 'Impact of IITA-improved germplasm on maize production in West and Central Africa'. *Impact*, IITA, Ibadan, Nigeria, pp.13.
[2] Hartwig N.L. and Ammon H.U. (2002). Cover crops and living mulches. *Weed Science, 50*(6), pp. 688-699.

sufficient to draw conclusions. Therefore, a second year study is required to collect data in other SI domains that were not captured during the first year and to draw useful conclusions
2. Objectives
2.1 Determine the effect of cowpea living mulch on weed population in a maize-cowpea cropping system
2.2 Evaluate the effect of cowpea living mulch on soil properties in a maize-cowpea cropping system
2.3 Determine the effect of cowpea living mulch on maize grain and fodder yields
2.4 Evaluate the effect of gender on the yield of maize under cowpea living mulch
2.5 Generate technology extrapolation domains in West Africa
3. Research questions
3.1 How does cowpea living mulch affect weed control under maize production?
3.3 How does cowpea living mulch affect soil moisture and temperature?
3.4 How does cowpea living mulch affect maize yield?
3.5 What are the preferences of male and female farmers for living mulch?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
4.1 Agronomic design: Randomize complete block design (RCBD)
4.2 Gender: Survey
4.3 The effect of four levels of cowpea living mulch (No living mulch, cowpea and maize same day, cowpea one week after maize, Cowpea two weeks after maize) and maize maturity type (Extra-early: Abontem; Early, Omankwa; Medium, Obatanpa) on weed control, soil characteristics and grain yields of maize will be determined using a 4 x 3 factorial treatment arrangement in a randomized block design. Trials will be conducted with farmers in the community parks and on selected farmers' fields. A gender survey and a farmers' field day will be conducted to evaluate male and female preferences. Technology extrapolation domain will be developed to identify suitable areas for scaling out.

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Weed diversity and biomass, maize grain and fodder yields	IITA
5.2 Gender: access to labor, timing and frequency of farm operations, decision making at farm level	IITA
5.3 Soil characteristics (temperature, moisture, nutrients)	IITA/ CIAT
5.4 GPS coordinates for all experimental sites	IITA

6. Milestones

Deliverables	Means of verification	Date
6.1 Agronomic and gender preference for technology data	Project annual report	Dec. 2018
6.2 Cost-benefit and labor input data	Project annual report	Dec. 2018
6.3 Technology extrapolation domain	Maps	Aug. 2019
6.4. Database on living mulch in maize	Dataverse	Dec. 2019
6.5. Paper published: Cowpea living-mulch effects on maize grain yield, vegetation cover and soil moisture dynamics	Paper in peer-reviewed workshop proceeding. Land Use Policy	Dec. 2020

7. Sustainable intensification indicators	
7.1 Productivity	Crop productivity at plot/ field and farm level
7.2 Environmental	Soil quality at the plot/ field level
7.3 Economic	Profitability and input use efficiency at the plot/ field level
7.4 Social	Gender equity at the plot/ field level
7.5 Human	Food security at plot/ field level

Sub-activity GH111A-1804: Intensify and diversify irrigated smallholder vegetable production systems - Leader: Jean-Baptiste Tignegre

Dry season irrigated vegetable (pepper, eggplant, tomato and onion) production for food and cash are widespread in the intervention communities in Ghana. Limited access to seeds of improved varieties, water for dry season irrigation and inappropriate agronomic practices (seeding rate, fertilization, disease control, pest management, etc.) are among the major constraints to production. In a previous survey, farmers ranked post-harvest losses in vegetable production as topmost constraints. In rural areas with reduced occurrence of market days, simple technologies such as zero cooling energy chambers can improve the shelf-life of leafy and fruit vegetables until the following market day. Vegetable research in Phase 1 of the project focused on limited varietal evaluation and assessment of various maize-vegetable cropping systems with limited community involvement. In 2018, varieties of vegetable species requested by farmers (pepper, eggplant, tomato and onion), good agronomic and adapted post-harvest practices will be evaluated with farmers' interest groups in the Upper East and Northern Regions of Ghana. Field days will be organized to document male and female farmers' preferences for the various technologies and practices. The vegetable activities will be related to training activities on good agricultural practices to develop knowledge and skills in implementing vegetable gardens in the Upper East and Northern Regions of Ghana (See protocol GH211-17).

2. Objectives

2.1 Evaluate varieties of known and little-known vegetable species under rainfed and irrigated conditions with farmers

2.2 Promote information and knowledge exchange among farmers

2.3 Train Farmers on good agricultural practices in vegetable gardens techniques

3. Research questions/hypotheses

3.1 Leaf and/or fruit yield of improved and local varieties of vegetable crops of different species will not differ significantly under irrigation conditions.

3.2 Good agronomic practices can significantly increase leaf and/or fruit yield of varieties of different crop species under irrigated conditions in the dry season and under rainfed conditions.

4. Procedures

Sub-activity GH111A-1804-1: Identification of varieties of vegetable crop species adapted to the Upper East and Northern Regions of Ghana under rainfed conditions- Leader: Jean Baptiste Tignegre

This activity is new. Rainy season vegetable production activities are relatively cheap and generate higher income for farmers when high yielding and farmers' preferred varieties are involved in the production. Humid season adapted tomato, pepper varieties are proposed in 2018 rainy season to face shortages of vegetable produces that usually prevail in the rainy season and to serve as a source of income for women and youth).

At least sixty farmers including 30 women (50%) and 30 young farmers aged 18 to 30 years old (50%) in the communities of Guia, or Niangua or Tekuru (UER) and Douko or Cheyohi (NR) will implement variety trials and demonstrations at the vegetable hubs, at selected IWMI technology parks, and on farmers' fields to test rainfed tomato and pepper varieties to select high-yield and disease-resistant

varieties. The field design will be randomized complete blocks with 4 replicates in Africa RISING technology parks; non-lead farmers will test a single replicate of the above varieties across 2 Regions (UER & NR); farmers will test a single replicate of the above species. Farmers will plant at least 3 improved varieties of each species including farmers' variety as control variety. The technology parks will host the replicated trials. Field days will be organized to document farmers' preferences for improved varieties and production practices. Participatory testing and diffusion of promising new vegetable cultivars will be carried out to deliver high value, multiple disease-resistant cultivars in the rainy season. Data will be collected for leaf and fresh fruits yield, varietal performances to plant diseases, farmers' perceptions and climatic data (annual rainfalls). Data will be collected on dry season trials and demonstrations. Gender studies will concern tool development and the introduction of research assistants to the tool through a skype conference. Under the responsibility of the Nutrition team (M. Saaka), the Nutrition media shows will include awareness on enriched vegetable products such as high vitamin A containing tomato varieties to ease their adoption and consumption by communities in Northern Ghana. This sub-activity is linked to gender and nutrition activities in Northern Ghana.

Sub-activity GH111A-1804-2: Identification of varieties of vegetable crop species with adaptation to Northern Ghana in the dry season - Leader: Jean-Baptiste Tignegre

High beta-carotene containing varieties were introduced in 2017 for the implementation of the nutrition-sensitive agriculture option. Although high yielding lines, farmers could not sell extra production because the market did not accept the orange colored skin. New lines that meet both farmers' and the market requirements are proposed in 2018 to ease technology uptake. In the meantime, nutrition communication for behaviour change will be implemented to facilitate the adoption of Vitamin A enriched tomatoes. New fresh pepper varieties with higher pungency are proposed to farmers in 2018 for own consumption and the market.

About ninety farmers in communities of the Upper East and Northern regions including at least 50% of female farmers and 50% of youth will implement variety trials and demonstrations at the vegetable hubs and/or selected IWMI crop hubs and farmers' fields to disseminate tomato, onion and pepper varieties. In the dry season, about 3 replicated trials will be conducted at these hubs under drip irrigation. Variety demonstrations will be conducted in the Upper East and Northern regions on selected farmers' fields (with shallow wells, dugouts, dams) to test at least 3 varieties of tomato, onion and pepper and select high-yielding and disease-resistant varieties. A randomized block design with 3 replicates will be used for trials in the IWMI hubs. Farmers will test a single replicate of the above species for at least 3 improved varieties of each species including farmers' variety as control variety. Field days will be organized to document male and female, old and young farmers' preferences for the various technologies and practices.

IWMI will provide three vegetable hubs available in Northern Region of Ghana equipped with drip systems to host replicated vegetable trials on tomato, pepper and onion. A trial on fertilizer dose response x water regimes on pepper will also be conducted in these hubs under IWMI responsibility. IWMI will collect data on fertilizer dose x water regimes, whilst WorldVeg will collect data on leaf and fresh fruits yield, plant diseases and farmers' perceptions.

The use of radio sequences as a communication tool by the Nutrition team in the Northern Region of Ghana for communities' behavior change will cover vegetable intervention areas. Gender studies will concern tool development and the introduction of research assistants to the tool through a skype conference.

This sub-activity is linked to water management and nutrition activities in the Northern Region of Ghana.

Sub-activity GH111A-1804-3: Improve the capacity of vegetable farmers on vegetable gardening and post-harvest techniques- Leader: Jean Baptiste Tignegre

This activity was part of the workplan last year but needs to be implemented for continued empowerment of farmers to achieve the output.
The activity aims at providing vegetable farmers with training on vegetable gardens. The training sessions will focus on topics such as good agricultural practices for the implementation of nurseries, production itinerary, post-harvest and vegetable processing, scaling up and use of Zero Energy Cool Chamber. Two vegetable varieties of promising lines of African eggplant, amaranth and high vitamin A containing tomato will be set up at IWMI hubs for observation and for awareness-raising.

5. Data to be collected and uploaded	
5.1 Days to 50% flowering	WorldVeg
5.2 Number of plants bearing fruits per plot; fruit yield (kg/ha)	WorldVeg
5.3 Leaf yield	WorldVeg

6. Milestones		
Deliverables	Means of verification	Date
6.1. Reports on field evaluation trials of the improved varieties as compared to local varieties	Reports	Apr. 2019
6.2. Database on vegetables	Dataverse	Apr. 2019
6.3. Paper on Performance of vegetable varieties under irrigation'	Paper available online or in a proceeding	Oct. 2019
6.4. 150 farmers trained on vegetable gardens implemented in Upper East and Northern Regions of Ghana	Training report	Nov. 2018
6.5. Report on farmers' participatory variety selection	Report	Dec. 2018
6.6 Contribution to technology handbook: Introduction section of chapter 1 on vegetable varieties; chapter 2 on Maize -vegetable (tomato, pepper, eggplant, okra, roselle) intercropping	WA technology handbook	Oct. 2018

7. Sustainable intensification indicators	
7.1 Productivity	Crop productivity (Crop yield); Cropping intensity over two seasons per year at the plot and farm levels
7.2 Environmental	Ground cover and water productivity at the plot level
7.3 Economic	Profitability and input use efficiency at the plot and farm levels
7.4 Social	Gender equity at the farm and household levels
7.5 Human	Nutritious food production at the plot and farm levels

8. How will scaling be achieved?

Scaling will be achieved through strategic partnerships with development partners. Knowledge transfer and scaling strategies will include: establishment of research-for-development plots to demonstrate technologies; participatory and joint learning approaches for technology testing, e.g., Community-based Technology Parks; development of media materials (posters, leaflets) for extension staff, farmers, etc., training of trainers and hands-on training for farmers.

9. How are the activities in this protocol linked to those of others?

Activities have links with following protocols: GH211-18: Increase the capacity of farm families, especially women to produce and consume diverse and more nutritious food. GH112-18: Test and disseminate a combination of improved breeds, housing, feeding, health and breeding practices to intensify rearing of livestock (sheep, goat, pig, and poultry) for meat, egg and milk production.

Budget Line	IITA	UDS	WorldVeg
Personnel	15,000	2,000	21,000
Services	44,650	4,000	4,000
Supplies	73,000	0	7,517
Capital	93,500	0	0
Travel	16,000	2,000	10,000
Overhead	0	1,200	7,483
Total	**242,150[1]**	**9,200[2]**	**50,000**

[1]Includes cost of vehicle running and maintenance of the 25 intervention communities in the Northern (Tamale), Upper West (Wa) and the Upper East (Navrongo) regions. Includes 15,000 for graduate training

[2] Allocated by IITA to UDS

2018 Africa RISING West Africa Activity Protocol – Outcome 1: GH111B-17				
Outcome 1: Farmers and farming communities in the project area are practicing more productive, resilient, profitable and sustainably intensified crop-livestock systems linked to markets.				
a. Output: 1.1	Research products for more productive, intensive, diverse, profitable and resilient crop (cereals, legumes, vegetables); livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities			
b. Activity: 1.1.1	Test a combination of climate-smart crop varieties and agronomic practices to increase and sustain food and feed production			
c. Sub-activity: GH111B-18	Finalize Aflasafe carry-over efficacy trials and obtain registration of two Aflasafe products with Ghana-Environmental Protection Agency for use in Ghana at scale			
d. Research team				
Name	Institution	Role		
Ranajit Bandyopadhyay	IITA	Guidance		
Alejandro Ortega-Beltran	IITA	Management and reporting		
Richard Awuah	KNUST	Guidance		
e. Student(s)				
Name	Institute	Degree	Start	End
1 Daniel Agbetiameh	KNUST	PhD	2014	2018
2				
f. Location(s)	Northern Region			
g. Start	August 2018			
h. End	December 2018			
1. Justification				
Use of Aflasafe is a proven technology to both displace aflatoxin producers in the field and reduce crop aflatoxin content. Aflatoxin contamination is reduced before, during, and after harvest, until				

consumption. In April 2018, both Aflasafe GH01 and Aflasafe GH01 received registration approval by Ghana's Environmental Protection Agency. Both products now can be used as a part of an integrative aflatoxin management strategy to protect maize, groundnut, and sorghum from aflatoxin contamination. Both products were launched on June 25, in Accra, and are ready to be commercialized for use at scale throughout Ghana.

Feld efficacy trials were not conducted in sorghum, however, Aflasafe would be effective in sorghum because time of infection, grain structures colonized, route of infection and basic epidemiology of the disease is similar in maize and sorghum. However, the technology needs to be further optimized to achieve greater benefits. We have been conducting studies to determine the frequency of application, the persistence of atoxigenic Aflasafe strains in treated soils, and the carry-over of atoxigenic strains from one season to the next. The third and final year of the carry-over study was conducted during 2017. This investigation has been conducted in the past two years and needs to be finalized in the 2017 cropping season. Chemical and microbiological analyses are currently on-going in the laboratory.

2. Objectives

2.1 To finalize analyses of Aflasafe carry -over trials in Ghana

2.2 To develop guidelines indicating the mode and frequency of application of Aflasafe products in each region and cropping system

3. Research questions

3.1. How often do farmers need to treat their fields with aflasafe to achieve aflatoxin-safe crop?

3.2 Do atoxigenic strains composing Aflasafe displace toxigenic fungi in treated fields and limit aflatoxin contamination during multiple years?

4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)

Chemical (toxin) analyses of samples from the carry-over trials have been completed during the first half of 2018. Microbial analyss of fungal communities associated with treated an un-treated crops is on-going and results will be ready by October 2018. Then,

A total of 120 maize fields were used during the final year of the carry-over study. For each Aflasafe product, 60 maize (farmers') fields in a randomized complete block design of six treatments with 10 replications (fields)/ treatment were used. In treatment 1, fields were treated in alternate years with Aflasafe within the period of the experiment. In treatment 2, fields were inoculated consecutively in all three growing seasons. Fields in treatment 3 were inoculated only in the first and second growing season while in treatment 4, field application was carried out only in the first growing season. Fields in block 5 were not treated in the first two cropping seasons but were treated only in the third and final year. Fields in block 6 served as a control with none of the fields inoculated throughout the study period. Field soil samples (100 g) were collected before application of Aflasafe and at harvest to analyze microbial population structure. In addition, crop samples (30 maize ears/field) were collected at harvest for chemical (aflatoxin) analysis on grains. Conscious efforts were made to include youth and female farmers in this trial. During the second half of 2018 analyses will be finalized, data will be summarized, analyzed and used to prepare recommendations on frequencies of Aflasafe application in maize and groundnut.

5. Data to be collected and uploaded	Responsibility/ Institute
5.1 Baseline data on farmers and coordinates of fields	Daniel Agbetiameh/ IITA
5.2 Data on chemical (aflatoxin) analysis	Daniel Agbetiameh/ IITA
5.3 Data on microbial analysis	Daniel Agbetiameh/ IITA

6. Milestones

Deliverables	Means of verification	Date
6.1 Guideline manual indicating mode and frequency of application of aflasafe products in each region and cropping system.	Manual produced by IITA	Dec. 2018
6.2 Published journal paper "Efficacy of both aflasafe products in reducing aflatoxin accumulation" intended for 'Plant Disease' or 'PLOS ONE'	Acceptance by the Journal	Dec. 2018

7. Sustainable intensification indicators	
7.1 Productivity	Crop yield at field and farm levels
7.2 Environmental	Biopesticide use at plot level
7.3 Economic	Profitability and input use efficiency and the plot and farm levels
7.4 Social	Gender equity at the farm and household levels
7.5 Human	Production of nutritious foods at the farm and household levels

8. How will scaling be achieved?
Both Aflasafe products developed for use in Ghana have been registered and are available for use by maize, groundnut, and sorghum farmers across Ghana. The products were launched on June 25, in Accra, Ghana. IITA has signed a distribution agreement with the company Macro Fertile and is in the process of identifying key partners for production of both Aflasafe products for use at throughout Ghana—the products are currently manufactured in Ibadan, Nigeria. These efforts are part of the Aflasafe Technology Transfer and Commercialization Project, funded by USAID and the Bill & Melinda Gates Foundation. Scaling up the use of Aflasafe is being done in collaboration with the government of Ghana, non-governmental organizations (NGOs), and private sector actors interested in improving maize and groundnut value chains as well as enhance the nutritional status of farm households. Producers (farmers) are being linked with premium markets and processors seeking aflatoxin-safe maize and groundnut. Training on aflatoxin and its management, using Aflasafe, was conducted for technical staff of staff of ADRA/Amplifies-Ghana and their partners. This included Agricultural Extension Agents (AEAs) from MoFA at the District level. Training was also given to personnel from PPRSD of MoFA, EPA and AFAP on aflatoxin and the science of Aflasafe as a strategy for mitigating aflatoxin contamination in target crops. Those trainees have been well equipped to provide step-down training on the subject to over 200 agro-input dealers in Northern Ghana in July, at the time of application in commercially-grown crops.
9. How are the activities in this protocol linked to those of others?
Linked to protocol GH111A-17 Aflatoxin-safe maize/groundnut from treated fields can be used in studies involving the poultry/livestock feeding trials as well as for studies on household nutrition for children under 5 years. Aflatoxin-safe crops are expected to be available in large quantities after 2018 cropping season. Leaders of activities that may benefit from incorporating aflatoxin-safe crops (livestock, nutrition) into their research will be contacted during the planning of 2019 activities.

10. Budget (USD)	
Budget Line	IITA
Personnel	6,000
Services	3,500
Supplies	5,500
Capital	0

Travel	0
Overhead	0
Total	**15,000**

2018 Africa RISING West Africa Activity Protocol – Outcome 1: GH112-18				
Outcome 1: Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.				
a. Output 1.1	Research products for more productive, intensive, diverse, profitable and resilient crop (cereals, legumes, and vegetables); livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities.			
b. Activity 1.1.2	Test and disseminate a combination of improved breeds, housing, feeding, health and breeding practices to intensify rearing of livestock (sheep, goat, pig, and poultry) for meat, egg and milk production.			
c. Sub-activity GH112-1801	Efficient feed utilization through improved feed troughs			
d. Research team				
Name	Institution	Role		
Augustine Ayantunde	ILRI	Coordination of sub-activity, training in the design of improved feed troughs and use, data analysis and final report		
Sadat Salifu	ARI	Coordination of training of farmers, data collection and report of the training		
Solomon Konlan	ARI	Assistance with data collection		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	Duku and Tibali (Northern region), Gia (Upper East)			
g. Start	July 2018			
h. End	March 2019			
1. Justification				
Seasonal feed scarcity, particularly in the dry season, is the norm in the Sudano-Sahelian zone of West Africa. The ad-hoc manner of feeding the available feed resources by the smallholder farmers is characterized by waste as animals eat part, and trample and urinate on the rest. Given the feed shortage particularly in the dry season, efficient utilization of the available feed resources is essential to minimize waste to feed more animals. Under the Africa RISING project in Ethiopia, improved feed troughs have been designed, tested and evaluated for feeding ruminants (cattle, sheep and goats) by ILRI. Results from monitoring of the use of the improved feed troughs in four sites in Ethiopia showed that it saved 27% of the cereal and legume residues offered to the animals compared to the traditional feed troughs. Besides, the improved feed troughs led to a significant increase in the amount of manure				

collected. The success stories around this simple technology have led to an enquiry about the feasibility of testing the same technology in West Africa. This sub-activity, therefore, aims at testing, validating and demonstrating the effect of improved feed troughs on feed utilization by both cattle and small ruminants in the 2 regions (Northern and Upper East) in northern Ghana. Colleagues from ILRI Ethiopia will be engaged in this sub-activity to train ARI partner in the design and use of the feed troughs. The selected farmers will then be trained by ARI. Data will be collected on the amount of feed offered, the waste, cost and benefit, farmers' assessment of the usefulness of the improved feed troughs, and household labor expenditure on feeding the animals.

2. Objectives

2.1: The overall objective of this sub-activity is: (i) To test, validate and demonstrate the effect of improved feed troughs on feed utilization by both cattle and small ruminants in the 2 regions in northern Ghana (Northern and Upper East regions). (ii) To build the capacity of smallholder livestock keepers in improved feeding systems to reduce waste and improve animal productivity.

3. Research questions

3.1 What is the effect of improved feed troughs on feed utilization by cattle and small ruminants, particularly on the reduction of feed waste?

3.2 What are the cost and benefit of the improved feed troughs?

3.3 What is the effect of the improved feed troughs on household labor allocation to animal feeding?

4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.).

Ten farmers will be selected randomly from each intervention community out of which three will be women who will be trained in the use of improved feed troughs for cattle and small ruminants. Each farmer will be provided with one improved feed troughs which will be compared with the traditional feeding practice. The designs of tmproved feed troughs will be presented to farmers for feedback. The amount of crop residue offered (both in the morning and afternoon) and that wasted during the feeding process will be measured for six consecutive days, both for the traditional practice (spreading a portion of the feed on the ground) and wooden troughs. The amount of time spent in looking after the animals while feeding (bringing back dispersed feed, keeping animals to feed comfortably) will be recorded for both practices. A survey questionnaire will be administered to all participating farmers to document their opinions about the contribution of the technology and its acceptance. A simple cost-benefit analysis will be done, considering the cost of construction of an average feed trough, the price of crop residues in the local market, and the total amount of the crop residue available for livestock feeding (to be derived from crop data). Samples of the feed offered, and the left-overs will be analyzed for both improved feed troughs and traditional feeding practice. Fodder biomass from leaf stripping in maize from agronomic trials will be used for testing of the improved feed troughs in some communities depending on the available quantity.

5. Data to be collected and uploaded	Responsibility/Institute
5.1: Quantity of feed offered and leftovers, the chemical composition of feed offered and leftovers, cost and benefit of the improved feed troughs, and time spent feeding the animals by different gender group.	A. Ayantunde/ILRI

6. Milestones

Deliverables	Means of verification	Date

6.1 Report of findings on testing and evaluation of the improved feed troughs compared to traditional practice	Report	Mar. 2019
6.2 Training report on improved feed troughs	Report	Dec. 2018
7 Sustainable intensification indicators		
7.1 Productivity	Input use efficiency (quantity of feed saved from waste)	
7.2 Environmental		
7.3 Economic	Profitability (cost and benefit of improved feed troughs)	
7.4 Social	Gender equity (time spent on feeding the animals by gender)	
7.5 Human		

8 How will scaling be achieved?	
Scaling will be done through partnerships with NGOs working on livestock and MoFA for the dissemination of the improved feed troughs. MoFA staff will be included in the training regarding the use of the improved feed troughs which will facilitate scaling.	
9 How are the activities in this protocol linked to those of others?	
Linked to protocol Leaf stripping in maize - Sub-activity GH111A-1802. The stripped leaves will be used as part of the feed for the animals.	

10. Budget (USD)	
Budget Line	ILRI
Personnel	26,585
Services	4,942
Supplies	1,743
Capital	0
Travel	7,600
Sub-Grantee: ARI	20,000
Sub-total	60,870
Overhead (15%)	9,130
Total	**70,000**

Sub-activity GH112-1802: Feed-health interventions for improved small ruminant production		
d. Research team		
Name	Institution	Role
Augustine Ayantunde	ILRI	Coordination of sub-activity, the design of survey instruments, data analysis and final report
Sadat Salifu	ARI	Coordinate data collection and entry, report of the survey administration, and geographic coordinates of the participating households
Shaibu Mohammed	ARI	Data collection and entry
e. Student(s)		

Name	Institute	Degree	Start	End

f. Location(s)	Tibali, Duku, Bontigle (Northern Region), Gia, Sambolgo, Nyangua (Upper East Region), Guo, Zanku and Passe (Upper West Region)
g. Start	August 2018
h. End	March 2019

1. Justification
Under the feed-health intervention study for improved small ruminant production in 9 intervention communities in 3 regions of Northern Ghana, we have collected data on animal performance (average daily gain, flock dynamics), manure production, and cost and benefit which covers the productivity, environmental and economic domains of the sustainable intensification assessment framework. We do not have the necessary data for the human and social domains regarding this feed-health intervention. The objective of this sub-activity is to collect data on the human and social domains so that we can assess the feed-health intervention based on the 5 domains of the sustainable intensification assessment framework. This sub-activity entails developing short survey instruments to collect data on how the feed-health intervention impacts on household food security and nutrition, and gender in terms of decision making and benefit sharing from the improved small ruminant production. The same households in the 9 communities involved in the feed-health intervention will be involved in the study. In addition to the additional data to be collected on feed-health intervention, a manuscript will be drafted and submitted to a journal for publication based on the study.
2. Objectives
2.1: The objective of this sub-activity is: (i) To collect additional data on social and human domains to assess the feed-health intervention based on the 5 domains of the sustainable intensification assessment framework.
3. Research questions
3.1 What is the effect of feed-health interventions on gender and household nutrition?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.).
The survey will be conducted on the perceived effect of feed and health interventions on gender equity and household nutrition, specifically the use of income from the sale of small ruminants on household food consumption and dietary diversity. The twenty farmers involved in the feed and health intervention in each community will be surveyed on their perception of the intervention on gender and household food and nutrition security. With the additional data on social and human domains, the sustainable intensification assessment framework will be used to assess the feed and health intervention. In addition, the data collected will be used for the chapter of the handbook on livestock technologies.

5. Data to be collected and uploaded	Responsibility/Institute
5.1: Household labor allocation by gender for managing small ruminants, decision making and sharing of benefits from the sale of small ruminants, the contribution of income from the sale of small ruminants to household food consumption and dietary diversity and coordinates of the participating households.	ILRI and ARI

6. Milestones		
Deliverables	Means of verification	Date
6.1 Data on the perceived effect of the feed-health intervention on household nutrition and gender equity	Report	Mar. 2019
6.2 Data on the effect of feed and health intervention on gender equity and household food and nutrition security	Report	Dec. 2018
6.3 Chapter on livestock technologies for the technology handbook	WA technology handbook	Oct. 2018
6.4 Draft manuscript on feed health intervention	Draft Manuscript	Mar. 2019

7 Sustainable intensification indicators	
7.1 Productivity	
7.2 Environmental	
7.3 Economic	Profitability (net income from the sale of small ruminants)
7.4 Social	Gender equity (time spent on small ruminant management by gender)
7.5 Human	Nutrition (household dietary diversity score)

8. How will scaling be achieved?	
The feed-health intervention will be scaled by MoFA through their various dissemination platforms.	
9. How are the activities in this protocol linked to those of others?	
Linked to the protocol on improved feed troughs – Sub-activity GH112-1801 as some of the data collection instruments developed for flock monitoring under feed-health intervention will be adapted for data collection on feed utilization with improved feed troughs. Besides, some households who have participated in the feed-health intervention will be selected for the testing of the improved feed troughs.	

10. Budget (USD)	
Budget Line	ILRI
Personnel	1,870
Services	318
Supplies	1,803
Capital	0
Travel	3,400
Sub-Grantee - ARI	10,000
Sub-total	17,391
Overhead (15%)	2,609
Total	**20,000**

2018 Africa RISING West Africa Activity Protocol – Outcome 1: GH121-18				
Outcome 1: Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.				
a. Output 1.2	Integrated management technologies and practices to improve and sustain productivity and ecosystems services of the soil, land, water and vegetation resources are developed and disseminated to farmers and development partners in the intervention communities.			
b. Activity 1.2.1	Test and disseminate land, soil and integrated land-soil technologies and practices to improve and sustain productivity and ecosystems services at the farm and landscape/watershed levels.			
c. Sub-activity GH121-18	Assess the impact of the combination of SWC interventions on soil moisture and nutrient fluxes for crop productivity within farming systems across an agro-ecological gradient in light of gender and socio-economic dynamics of target beneficiaries.			
d. Research team				
Name	Institution	Role		
Fred Kizito	IITA	PI: Land management strategies		
Wilson Agyare	KNUST	Co-PI: Soil-water dynamics		
Gundula Fischer	IITA	Gender mainstreaming		
Bekele Kotu	IITA	Economic studies		
Zenebe Adimassu	IWMI	Water management		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	Upper East (Bonia and Nyangua) and Northern (Tibali) regions			
g. Start	August 2018			
h. End	February 2019			
1. Justification				
During the 2016/17 season, work was conducted on rolling out soil and water conservation measures in selected farming systems to demonstrate their role towards in-situ moisture capture and storage, erosion reduction and climate risk adaptation. This was followed by cost-benefit analysis coupled with farmers' perceptions of gender and labor demands associated with soil and water conservation measures in farming systems. Despite the fact that these activities were successfully conducted, there are some loose ends regarding nutrient management that were not conducted. The proposed activities for 2018 will fill this gap. We envisage that activities which reduce soil and nutrient losses from the farm systems through soil erosion reduction interventions will subsequently increase root zone soil moisture storage and nutrient availability. This will offer vital information for nutrient management in crop agronomy as well as viable recommendation options that can be shared with extension personnel. Understanding nutrient dynamics within farming systems offers options for informed intensification towards optimal nutrient partitioning, avoided losses and environmental management, a necessary and critical step for technologies being promoted by AR-WA. The periodic measurement and monitoring of on-farm fluxes will continue in order to provide metrics that help evaluate the performance of the implemented interventions and provide a matrix against which econometric assessments will be conducted. We have explored how both gender and economic issues would evolve in light of regional integration. There are numerous lessons on adoption and uptake that still need to be unraveled in the area of gender dynamics and economics of soil and water management. Apart from conducting a second season to allow for publication of our results, knowing these also offers a step closer towards enhancing technology uptake. Beyond soil and water				

conservation, field observations in recent years have revealed that increasingly farmer planning on timing of planting and agronomic management practices (e.g. timing of sowing, thinning, fertilizer application, harvesting and storage) is often haphazard but if planned well offers numerous dividends (early crop vigor, drought avoidance, tolerance to pests and diseases). We have also proposed an integrated way of communicating and reaching out to our target audiences through having an ICT platform that combines agronomy, markets, climate services and postharvest info for the benefit of farmers.
2. Objectives
2.1 Assess the impact of the combination of SWC interventions on soil moisture and nutrient fluxes for crop productivity within farming systems across an agro-ecological gradient (including both gender and economic analyses)
2.2 Co-develop with partners and share with end users crop planning decision matrix that links soil characteristics, planting dates information complemented with the training of extension agents and development partners on use of the matrix for improved crop productivity thus developing both human and institutional capacity
2.3 Engage ICT and GIS tools as a means to share information and scale out soil and water conservation measures in collaboration with strategic partnerships in the Region
2.4. West Africa Handbook Chapter: Land and water management strategies in Cereal-Legume based farming systems
3. Research questions
3.1 How can we best assess the impact of the combination of SWC interventions on soil moisture and nutrient fluxes for crop productivity within farming systems across an agro-ecological gradient (including both gender and economic analyses)?
3.2. How can we co-develop and share with end users crop planning decision matrix that links soil characteristics, planting dates information complemented with the training of extension agents and development partners on use of the matrix for improved crop productivity thus developing both human and institutional capacity?
3.3 How can we engage ICT and GIS tools as a means to share information and scale out soil and water conservation measures in collaboration with strategic partnerships in the Region?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
Sub-activity GH121-1801: Assess the impact of the combination of SWC interventions on soil moisture and nutrient fluxes for crop productivity within farming systems across an agro-ecological gradient while capturing gender and socio-economic dynamics of target beneficiaries for climate risk adaptation - Leader: Fred Kizito
This will entail establishing soil and water conservation measures specifically, tied ridges and contour ridges as well as a control in farmers' fields. The study will build on the results from the 2016/2017 season to conduct a detailed analysis of the spatial and temporal trends of the data collected. The assessment will include evaluation of soil conservation practices towards environmental integrity (allowing moisture infiltration, reducing erosion and nutrient losses). This will also involve the use of GIS analysis and spatial modeling to scale-up and out proven land and soil management interventions that have a high potential for increasing agricultural productivity. The activity will be co-located within the agronomic trials.
Sub-activity GH121-1802: Co-develop with partners and share with end users crop planning decision matrix that links soil characteristics, planting dates information complemented with the training of extension agents and development partners on use of the matrix for improved crop productivity thus developing both human and institutional capacity - Leader: Fred Kizito

This activity builds on results derived from several years of local knowledge observations, research and climatic data in the region. It will entail working closely with communities while incorporating existing indigenous knowledge. It is envisaged that this activity will come earlier in the process and will involve close collaboration with other work-packages for co-planning of events. It will also involve reinforcing knowledge during and after the cropping season. This will also entail developing brochures and training manuals for educating and training farmers and extension officers on the cropping calendars. Beyond soil and water conservation, field observations in recent years have revealed that increasingly farmer planning on timing of planting and agronomic management practices (e.g. timing of sowing, thinning, fertilizer application, harvesting and storage) is often haphazard but if planned well offers numerous dividends (early crop vigor, drought avoidance, tolerance to pests and diseases).	
Sub-activity GH121-1803: Engage ICT and GIS tools as a means to share information and scale out Africa RISING technologies in collaboration with strategic partnerships in the Region - Leader: Fred Kizito	
This activity is an integrating activity across the interventions being promoted in Africa RISING. It will equally entail working closely with other work-packages for packaging the right messages, and the timing of message delivery to the end users. It will also involve awareness raising on the role and benefits of the platform including both farmers and extension officers. Some of the messages will be tailored around crop agronomy, climate services, market information, and post-harvest management practices.	
Sub-activity GH121-1804: West Africa Handbook Chapter: Land and water management strategies in Cereal-Legume based farming systems - Leader: Fred Kizito	
This will entail describing how successful lad and water-based management practices have been used within the context of Africa RISING. We shall describe the benefits and challenges and provide guidance on how to get started with soil and water conservation techniques. The chapter will also offer opportunities for the application of technology and targeting for particular areas.	
5. Data to be collected and uploaded	Responsibility/Institute
5.1 Assessing combinations of soil and water conservation measures: Measurements and metrics: • Soil losses will be monitored by a modified version of a calibrated runoff soil loss detector that captures 75% of the plot runoff zone; • Climatic variables: Rainfall, air temperature, wind speed and relative humidity for crop evapotranspiration measurements; • Nutrient dynamics will be monitored using suction lysimeters which will be held at a tension of 70 cbars and installed at varying depths along the profiles of interest in order to ascertain fate and transport as well as verify what percentage is captured within the crop root zone; • Soil moisture will provide vital links to both soil and nutrient losses. Soil moisture will be monitored using a diviner probe (Sentenk Inc.) to depths of 1.6 m at 10 cm increments within the profile. Access tubes for moisture measurement with the diviner probe will be installed in the center position of the target plots; • Infiltration rates with a portable mini-disk infiltrometer	F. Kizito/IITA and W. Agyare/KNUST
5.2 Co-develop with partners and share with end users crop planning decision matrix: • Climatic variables: Rainfall, air temperature, wind speed and relative humidity for crop evapotranspiration measurements; • Historical planting dates for major staples	F. Kizito/IITA and W. Agyare/KNUST

• Date calendars for agronomic practices (e.g. timing of sowing, thinning, fertilizer application, harvesting and storage)	
5.3 Develop both human and institutional capacity of target farmers towards improved soil and water conservation measures: We shall assess the knowledge, attitude, skills and aspirations of farmers before and after the trainings and capacity building exercises. We shall use the KASA framework to make these assessments. This activity encompasses all the 3 sub-activities of soil and water conservation, on crop calendar planning and the use of ICT for scaling and communication.	F. Kizito/IITA and W. Agyare/KNUST

6. Milestones		
Deliverables	Means of verification	Date
6.1 Technical brief on the dynamics of nutrient management in farming systems	Partner work plans (IITA/KNUST) Research Report	Dec. 2018
6.2. Crop planning decision matrix	Crop planning decision matrix rolled out	Nov. 2018
6.3. ICT platform	Functional ICT Platform with verifiable members, archives of messaging	Nov. 2018
6.4. Training manuals and brochures on soil and water conservation measures, cropping calendars and ICT	Research report including a list of participants, training agenda and brochures	Nov. 2018
6.5. A chapter on Land and water management strategies in Cereal-Legume based farming systems for technology handbook	WA technology handbook	Nov. 2018

7. Sustainable intensification indicators	
Domain	Associated indicators
7.1 Productivity	Crop productivity (Crop yield)
7.2 Environmental	Erosion, soil physical quality and soil chemical quality at the plot level
7.3 Economic	Profitability and Input Use Efficiency at plot and farm level; returns to productivity
7.4 Social	Gender equity and collective action in labor and other resource uses; and adaptive capacity of communities
7.5 Human	Capacity to experiment with the # of new practices being tested at the household level

8. How will scaling be achieved?
Strategic partnerships with both public and private sector entities for the public sector: we shall liaise with MoFA, the private sector, SNV (Stichting Nederlandse Vrijwilligers) and local universities. We envisaged that the targeted partners will be contacted and will be on board in August/September 2018. We shall involve the use of GIS analysis and spatial modeling to scale-up and out proven land and soil management interventions that have a high potential for increasing agricultural productivity while including crop suitability potential. This scaling mechanism will be developed and rolled out for the target sites by December 2018. The use of participatory video methods and maps will be used as information sharing methods in the target sites with partners and will complement the scaling-up and out through farmer to farmer exchanges on soil and land management interventions that increase on-farm productivity. We link up with on-going initiatives and partnerships such as Northern Agricultural Sector Working Group (NASWG) and NRGDP as scaling pathways for our research. This will include

sharing with them brochures developed for farmer training as well as co-sharing in-field experiences at working group discussions including MoFA as well.
9. How are the activities in this protocol linked to those of others?
Linked to protocols GH111A-18 and GH122-18 and numerous other work packages. This is an integrative activity in that CIAT, IITA, IWMI, and KNUST will collaborate on soil and water conservation incorporation within farming systems. The work also closely links with IITA on cereal-legume cropping systems and will mimic the soil and water conservation approaches that incorporate living mulch in farming systems that have been successfully implemented previously in West Africa. Insights from our work will be shared with IWMI for cross-learning opportunities between soil/land management strategies and water management interventions within the target farming systems. The activities on cropping calendars and ICT are all-encompassing, and the training and capacity building will be conducted in liaison with other work packages.

	10. Budget (USD)		
Budget Line	IITA	CIAT	KNUST
Personnel	15,000	0	13,000
Services	3,000	2,000	2,000
Supplies	6,000	0	2,000
Capital	3,700	0	3,000
Travel	0	0	2,000
Overhead	0	300	2,200
Total	**25,700**	**2,300**	**24,000**

2018 Africa RISING West Africa Activity Protocol – Outcome 1: GH122-18				
Outcome 1: Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.				
a. Output 1.2	Integrated management technologies and practices to improve and sustain productivity and ecosystem services of the soil, land, water and vegetation resources are developed and disseminated with farmers and development partners in the intervention communities			
b. Activity 1.2.2	Test and promote water management technologies and practices to increase water productivity in the small-scale crop-livestock farming systems under rainfed and irrigated conditions			
c. Sub-activity GH122-18	Research on agricultural water management under rainfed and irrigation conditions to improve water productivity in integrated crop-livestock systems of northern Ghana			
d. Research team				
Name	Institution	Role		
Zenebe Adimassu	IWMI	Agric. Water Management		
Bedru Balana	IWMI	Economic studies		
Richard Appoh	IWMI	Research officer (setup and collect data of all field trials)		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	Upper East Region (Nayngua and Tekuru communities)			
g. Start	August 2018			

h. End	April 2019

1. Justification:

Agriculture contributes about 25 % to Ghana's GDP while employing over 56 % of the labor force serving as the major source of livelihood for many rural communities in Ghana. In the northern part of the country, rain-fed agriculture is predominant, with a uni-modal rainy season from May to September and intra-seasonal droughts. Water is, therefore, a key limiting factor for production in spite of the average annual rainfall amounts exceeding 1,000mm/yr. A long dry season period in northern Ghana offers an opportunity for farmers to intensify and diversify their production systems. Currently, only a small proportion of the cropland in northern Ghana is under more than one crop cycle per year whereas surface and groundwater resources are abundant on annual basis to realize double or triple cropping. For example, in the Anyari transboundary watershed which has an area of 253km^2 within Ghana and which has some of the Africa RISING vegetable hubs shows that harvesting just 10% of the surface runoff by using dams, dugouts and underground tanks can support an irrigable area of 1,750ha which could be used for dry season agriculture (Ofosu-Antwi et al., 2017)[3]. In addition to surface water, the groundwater resources can irrigate up to 4,500ha of land sustainably without any water stress. Upscaling irrigation in the Anyari catchment to 6,250ha would lead to only 0.01% reduction in stream flow to Akosombo dam downstream of the Volta. When the untapped resources are explored, together with other considerations such as access to inputs, credit, market, and good agronomic practices, dry season production system that responds to local and regional price fluctuations in major commodity crops could provide an additional source of income for farming households (Miescher 2014)[4].

Although water management solutions offer greater security to agricultural production and expand the options for sustaining livelihoods as well as ensuring food security and nutrition (Domenech, 2015)[5], the efficiency of water in agricultural production is low at farm level. Generally, only the crop effectively uses 40 to 60% of applied water, the rest is usually lost through various processes including evaporation, runoff, and percolation into the groundwater. It is therefore critical to develop agricultural water management strategies with smallholder farmers to attain better productivity and efficiency of water for sustainable intensification, and contribution to Sustainable Development Goals (SDG), especially SDG 6.3 for water productivity improvements.

A first step is to ensure that the right amount of water is applied at the right time to avoid needless waste of water and energy. Unfortunately, many small-scale farmers do not have the knowledge and tools for determining the right amount of water and time to apply. Irrigation scheduling ensures that water is optimally available to the plant if applied according to crop requirements. However, irrigation also incurs a cost for labor and energy so the optimal water allocation from the biophysical and crop production perspective should coincide with the economic optimal water productivity. Simple decision support tools can be used to guide farmers on when to irrigate and in what amount. Such tools can be used by irrigation officers, agronomist, agricultural extension agents and some farmers, with minimal training. Although it has been applied to some elected formal irrigation schemes in Ghana, its adaptability to smallholder single farm units is yet to be proven. IWMI introduced the wetting front detectors (WFD) during phase 1 of AR in Ethiopia and in Ghana. While in Ethiopia, the use of WFD in guiding supplementary irrigation of oats and vetch resulted in 64% yield increase, the investigation in Ghana has so far been constrained by multiple factors. Research is needed to

[3] Ofosu-Antwi, E., Annor, F. and Mul, M. 2017. Quantification of surface and groundwater resources in the Anyari watershed of the Upper East Region in Ghana. Ibadan, Nigeria: IITA.

[4] Miescher, S.F., 2014. "Nkrumah's Baby": the Akosombo Dam and the dream of development in Ghana, 1952–1966. Water History, 6: 341–366.

[5] Domenech, L., 2015. Improving irrigation access to combat food insecurity and undernutrition: A review. Global Food Security 6: 24-33.

understand to what extent the access to scheduling tools such as the WFD tools would improve crop and water productivity. Researchers usually compare measurement within a framework of accuracy. From the perspective of the farmer, attributes such as the ability to try out the technology on a small scale, economic feasibility, willingness to pay, compatibility with current practice and the management of risk are crucial. These factors, together with the farmer's own assessment of accuracy, combine to determine the relative advantage of a new tool such as WFD over farmers practice. Hence, this study will also assess the economic feasibility and farmers' views regarding the use of WFD for irrigation scheduling.

Sub-activity GH122-1801: Determining appropriate water scheduling methods for enhanced crop and water productivity in dry season vegetable production: Activity Leader – Zenebe Adimassu

Irrigation scheduling technologies such as WFD will be tested in the vegetable hubs (5 farmers; field) located in Nayngua and Tekuru in collaboration with World Vegetable Centre. Wetting Front Detector, a sensor-based simple tool will be tested on pepper which was selected by farmers in 2017 growing season. The tool indicates when the root-zone is dry and when it becomes saturated during irrigation. The water productivity using the sensors will be compared against i) a fixed irrigation schedule and ii) the farmers' normal practice. Organo-mineral and mineral fertilizers rates will be tested with watering regimes. The experiment will provide an opportunity for farmers to compare the tested irrigation scheduling methods (Wetting Front Detector, crop water requirements and farmer practice) with respect to income, water, labor and time savings.
This study was started in the 2017 research year. However, data were not sufficient to draw a conclusion and provide recommendations. Hence this activity will be conducted in 2018 to generate additional data that can be used for economic study and confirm the first year's results.

Sub-activity GH122-1802 Assess economic feasibility and farmers' views on the wetting front detector (WFD) irrigation scheduling tool for dry season vegetable production system in two communities (Nyangua and Tekuru), Upper East Region of Ghana - Leader: Bedru Balana

Based on lessons learned from Africa RISING phase 1, it is recommended to involve socio-economic studies to ensure that technologies are economically feasible and socially acceptable. At present, little evidence is available on economic feasibility and social acceptability of using WFD in the study areas. This study seeks to contribute to filling the gap in knowledge, particularly about potential returns to farmers and improving investment decision-making in WFD as irrigation scheduling tool. Using primary farm-plot level data and secondary data from relevant sources, this study will present evidence on the economic feasibility of investing in WFD and farmers' acceptability.

2. Objectives:

2.1 Assess the effectiveness of the Wetting Front Detector (WFD) irrigation scheduling tool for dry season vegetable production system and the implication on crop water productivity

2.2 Assess economic feasibility and farmers' views on the wetting front detector (WFD) irrigation scheduling tool for the dry season vegetable production system in two communities

3. Research questions

3.1. How effective is the WFD for crop and water productivity in dry season vegetable production?

3.2. How are irrigation scheduling tools (WFD) economically feasible and socially acceptable by farmers?

4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)

4.1. Field experiment on irrigation scheduling methods (GH122-1801)

This activity is the continuation of sub-activity GH122-1702. Accordingly, this experiment will be conducted in the dry season (November 2018-March 2019). Pepper (scotch bonnet) will be used as

test crop. A split plot design will be used in which water regimes (n=3) are the main plots and fertilizer rates (n=6) are sub-plots. The experiment will be conducted in vegetable hubs of 5 farmers' field. Farmers are considered as replicates.

4.2. Economic feasibility of wetting front detector as irrigation scheduling tool (GH122-1802)
The main task is to assess the economic feasibility of WFD using data generated in the previous years' field trial from five vegetable hubs of Africa RISING project. Cost-benefit analysis or marginal rate of return will be used to understand the economic feasibility of WFD under smallholder farmers in the study area.

5. Data to be collected and uploaded	**Responsibility/Institute**
5. 1. Irrigation scheduling methods • Yield (kg/plot) • Irrigation quantity applied (mm) • Fertilizer (type, quantity, cost) • Labor involved Cost of other inputs such as nursery establishment	IWMI
5. 2. Economic feasibility and farmers' views • Yield (kg/plot) • Input usages (agricultural inputs, irrigation inputs/costs, labor) • Input and output prices • Plot sizes and crop types • Demographic and individual characteristics • Farmers' perceptions of the technology (qualitative) Willingness to pay (this may include both 'stated' and 'revealed' data)	IWMI

6. Milestones		
Deliverables	Means of verification	Date
6.1. Recommendations on irrigation scheduling methods for enhanced crop water productivity in the dry season	Report to be published on CGSpace on appropriate irrigation scheduling methods for enhanced crop and water productivity in dry season vegetable production	Apr. 2019[6]
6.2. Evidence on economic feasibility and acceptability of irrigation scheduling tools	Project report published on CGSpace on economic feasibility and acceptability of irrigation scheduling	Apr. 2019

7. Sustainable intensification indicators	
7.1 Productivity	Crop productivity (Yield (kg/plot, kg/ha)
7.2 Environmental	- Water availability: days during growing season without adequate soil moisture for crop growth (farm level) - Soil: % C at each soil depth, Total amount of soil Carbon (farm level) - Pesticide use: Quantity applied per ha by type (farm level)
7.3 Economic	- Profitability (farm level) - Input use efficiency: water use efficiency (kg/m^3) (farm level)
7.4 Social	Level of collective action: Participation of farmers by gender in irrigation water use (household level)

[6] Moreover, by combining the 2017 and 2018 technical reports, a manuscript will be prepared and submitted to a journal by September 2019.

7.5 Human	Food safety: Pesticide application (#/ha and toxicity (farm level)

8. How will scaling be achieved?	
Scaling will be achieved by organizing stakeholder meetings with farmers (n=30) and extension officers (n=4) on the results of the trials, the preferred water scheduling and application methods during the dry season. The project team will share the research results and engage with potential scaling partners in the Northern Agricultural Sector Working Group (NASWG), which is a dialogue platform for engaging the government and Development Partners in the realization of the agriculture policy in the north. Co-generation of knowledge through on-farm demonstration will be used to scale out innovative technologies.	
9. How are the activities in this protocol linked to those of others?	
This experiment is linked to sub-activities GH122-1702 and activities planned by WordVeg such as GH111A-1804-1 and GH111A-1804-2. The outcomes of these research help to disseminate vegetable production in north Ghana and other areas with similar biophysical and socio-economic settings.	
10. Budget (USD)	
Budget line	IWMI
Personnel	52,850
Consultant	1,356
Services	20,340
Supplies	695
Capital	0
Travel	8,759
Overhead	15,389
Total	**99,389**

2018 Africa RISING West Africa Activity Protocol – Outcome 1: GH133-18				
Outcome 1: Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.				
a. Output 1	Post-harvest technologies and practices to provide options for the food and feed sectors are tested and disseminated to farmers, through researchers, extension staff, and development partners.			
b. Activity 1.3	Introduce, evaluate, adapt and disseminate existing post-harvest technologies and practices			
c. Sub-activity GH131-18	Demonstrate small-scale maize shelling machines to smallholders and other stakeholders to reduce drudgery and labor requirements			
d. Research team				
Name	*Institution*	*Role*		
Bekele Kotu	IITA	Activity leader		
Abdul Rahman Nurudeen	IITA	Linkage with farmers/ stakeholders		
Fred Kizito	IITA	Advisory support		
e. Student(s)				
Name	Institute	Degree	Start	End

f. Location(s)	Locations: Northern Region, Upper West Region, and Upper East Region
g. Start	August 2018
h. End	March 2019
1. Justification	
Mechanization is an important complement, and in some cases, a necessary condition, to agricultural intensification. It constitutes several implements and machines which can substitute or supplement human labor to carry out energy/power intensive operations (such as land preparation, harvesting and threshing) as well as control intensive operations (such as planting and weeding) (Pingali, 2007[7]). While agricultural mechanization played a great role during the Asian green revolution, current scholarly opinions indicate that mechanization can play even a better role to intensify African agriculture because of the fact that land-to-labor ratio is relatively high in many African countries such as Ghana, Tanzania, Nigeria, Senegal, and Zambia (Nin-Pratt and McBride, 2014[8]). That is, when existing land has to be more intensively cultivated, mechanization will be adopted to complement the higher labor demand to accomplish increased activities. Secondly, there are also arguments that agricultural operations are arduous by their nature and mechanization is necessary to reduce the drudgery. Drudgery has increasingly become important to explain the opportunity cost of labor, particularly for the youth, who can otherwise be engaged in less laborious urban-based employments although they may be less productive (Mrema et al., 2008[9]). Most of the laborious activities such as manual threshing are usually carried out by women and hence the adoption of mechanization may improve the welfare of women. Thirdly, the adoption of mechanization can also reduce harvest and postharvest grain losses. For instance, a study indicates that the use of a combine harvester could reduce grain losses by 20-35 percent as compared to manual threshing (Hassena et al., 2000[10]). In view of these advantages, in phase 1, the Africa RISING research team has introduced two types of shelling machines (i.e. diesel operated and electric operated machines) and conducted a study to assess the economic benefits of two type of small-scale maize shelling. Results show that the machines increase the labor efficiency among smallholder farmers while saving costs. Farmers can save up to 36 hours per ton of maize shelled if they use the shelling machines. The results also suggest that the potential demand for the technologies will be high if the machines are promoted. Therefore, this activity will demonstrate the machines to farmers and other stakeholders to facilitate further scaling.	
2. Objectives	
2.1. To demonstrate small-scale maize shelling machines to smallholder farmers and other stakeholders	
3. Research questions	
4. Procedures	

[7] Pingali, P. (2007). Agricultural Mechanization: Adoption patterns and economic impacts. In: R. Enanson and P. Pingali (eds.), Handbook of Agricultural Economics, volume 3, pp. 2780-2803. Elsevier B.V.

[8] Nin-Pratt, A., and McBride, L. (2014). Agricultural Intensification in Ghana: Evaluating the Optimist's Case for a Green Revolution. *Food Policy*. 48: 153–167.

[9] Mrema, G., Baker, D., and Kahan, D. (2008). Agricultural Mechanization in Sub-Saharan Africa: Time for a New Look. Rome: Food and Agriculture Organization of the United Nations.

[10] Hassena et al., 2000. *A comparative assessment of combined harvesting vis-à-vis conventional harvesting and threshing in Arisi region, Ethiopia.* Mexico, DF: International Maize and Wheat Centre (CIMMYT) and Ethiopian Agricultural Research Organization (EARO)

The shelling machines will be demonstrated in Africa RISING intervention communities in Northern Region, Upper West Region, and Upper East Region. People from the private sector, NGOs, and government offices will be invited to attend the demonstration events.		
5. Data to be collected and uploaded		Responsibility/Institute
The number and basic demography of attendants		Kotu/IITA
6. Milestones		
Deliverables	Means of verification	Date
Sheller Demonstrations	Report	December, 2018
7. Sustainable intensification indicators		
7.1 Productivity		
7.2 Environmental		
7.3 Economic	Labor use efficiency, cost per unit of output shelled	
7.4 Social		
7.5 Human		
8. How is the activity in this protocol linked to those of others?		
10. Budget (USD)		
Budget Line	IITA	
Personnel	0	
Services	1,000	
Supplies	2,000	
Capital	0	
Travel	2,000	
Overhead	0	
Total	**5,000**	

2018 Africa RISING West Africa Activity Protocol – Outcome 2: GH211-18		
Outcome 2	More farmers and farm families are adopting technologies and practices to improve nutrition, food and feed safety, post-harvest handling and value addition.	
a. Output 2.1	Improved technologies, practices and habits to increase production and consumption of diverse and more nutritious food by farm families, especially by women and children are developed	
b. Activity 2.1.1	Develop a nutrition strategy to harmonize the nutrition activities national nutrition approaches and link them to the crop and livestock activities	
c. Sub-activity GH211-18	Nutrition-sensitive agriculture: analyzing relations among indicators of human and environmental health for smallholder households as affected by sustainable farm production and dietary diversity	
d. Research team		
Name	Institution	Role
Jeroen Groot	WUR	Farming systems analysis (Activity Leader)
Katrien Descheemaeker	WUR	Farming systems analysis
Bekele Kotu	IITA	Economic analysis
Lieven Claessens	IITA	Farming systems analysis
Mahama Saaka	UDS	Nutrition and development

e. Student(s)				
Name	Institute	Degree	Start	End
Vacancy	WUR	MSc	09/2018	06/2019
f. Location(s)	Duko (Northern Region), Nyangua (Upper East Region), Zanko (Upper West Region)			
g. Start	09/2018			
h. End	10/2019			

1. Justification
Options to improve household diets and environmental sustainability are being tested and disseminated within Africa RISING. The performance of nutrition-sensitive interventions that aim for improved dietary adequacy and diversity should also be evaluated for effects on socio-economic and environmental system performance. What are the implications for labor requirements and the division of activities? How are household economics affected? What are the agronomic consequences of crop diversification, and how do choices about crop and animal production affect nutrient cycling, soil quality and water use? These questions necessitate an integrated analysis. We build on collected data and employ the FarmDESIGN model to quantify relations between dietary indicators (dietary diversity score, nutritional functional diversity, nutrient adequacy, food pattern) and with socio-economic and environmental indicators for selected households in the three northern regions of Ghana. We use a participatory approach to exchange insights with farm household members on choices on food production, market interactions and labor allocation.
2. Objectives
2.1 To analyze trade-offs and synergies among indicators of farm performance (economic and environmental), household nutrition, income and labor allocation
2.2 Exploring the potential role of proposed agricultural and nutritional interventions for improving human health through nutrition and environmental health through sustainable farming
3. Research questions
3.1 What are the farm-household trade-offs associated with alternative farm designs and food acquisition decisions for dietary adequacy and diversity, and for productive, socio-economic and environmental farm performance?
3.2 Do different household members see opportunities to adopt and implement proposed designs and food-related decisions?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
4.1 Selection of farm-households of different endowment levels and nutritional strategies from the selected villages are selected
4.2 Models are parameterized with survey data (GARBES and WUR survey) and build on earlier modelling efforts with the FarmDESIGN model

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Interactions with farmers and their household members are monitored. Model parameters are stored and made available. Visualizations may be added. Data for all variables, all households and household members will be made available to AR colleagues on Dataverse. Data must not be fully unlocked/used by anyone else than the	Jeroen Groot/WUR

authors until published in a peer-reviewed journal article or 12 months after completion of data collection.		
6. Milestones		
Deliverables	Means of verification	Date
6.1 MSc thesis and draft journal article: Interactions among nutritional and farming outcomes for smallholder households in Northern Ghana	Report uploaded	Jul. 2019
6.2 Blog on interactions with actors and outcomes of modelling	Published on Africa RISING website	Aug. 2019
7. Sustainable intensification indicators at farm level		
7.1 Productivity	Farm-level productivity (crop and animal products)	
7.2 Environmental	Nutrient losses, organic matter buildup in soil at farm level	
7.3 Economic	Farm operating profit and household income, expenditure on food	
7.4 Social	Differences in endowment and nutritional adequacy and diversity	
7.5 Human	Labor allocation, dietary adequacy and diversity	

8. How will scaling be achieved?
The modelling results will be discussed at farmer meetings. Findings will be shared and published.
9. How are the activities in this protocol linked to those of others?
GH211-18: Evaluation of nutrition-sensitive-agriculture options in West Africa.

10. Budget (USD)	
Budget Line	WUR
Personnel	5,000
Services	1,000
Supplies	700
Capital	0
Travel	1,250
Overhead	750
Total	**8,700**

2018 Africa RISING West Africa Activity Protocol – Outcome 2: GH212-18					
Outcome 2: More farmers and farm families in the intervention communities are adopting technologies and practices to improve nutrition, food and feed safety, post-harvest handling and value addition.					
a. Output 2.1	Improved technologies, practices and habits to increase production and consumption of diverse and more nutritious food by farm families, especially by women and children are developed and disseminated in partnership with research and development partners.				
b. Activity 2.1.2	Increase the capacity of farm families, especially women, to produce and consume diverse and more nutritious food				
c. Sub-activity GH212-1801	Using the power of radio to promote women's empowerment for improved agricultural productivity and nutrition outcomes				
d. Research team					
Name	Institution	Role			
Mahama Saaka	UDS	Sub-activity leader: Coordinates the design, implementation and evaluation of activities			
Chrisantus Daari	Ghana Health Service	Assists with training of women's groups, data collection and compilation of monthly reports on activities			
Lawal Alhassan	Ghana Health Service	Monitor sub-District field activities including the delivery of nutrition education, growth monitoring and home visits			
Jean-Baptiste Tignegre	WorldVeg	Coordinates the production of nutrient-dense vegetables in selected communities			
Mahama Saaka	UDS	Sub-activity leader: Coordinates the design, implementation and evaluation of activities			
Chrisantus Daari	Ghana Health Service	Assists with training of women's groups, data collection and compilation of monthly reports on activities			
e. Student(s)					
Name	Institute		Degree	Start	End
f. Location(s)	25 communities in 5 districts (Savelugu, Tolon, Wa West, Nadowli and Kassena-Nankana) of northern Ghana				
g. Start	July 2018				
h. End	May 2019				
1. Justification					
Childhood malnutrition is a global public health problem in many parts of the world including northern Ghana. Potential interventions and strategies are being sought for a lasting solution. One such intervention is the promotion of women's empowerment as an important point for improving childhood nutrition[1]. There is evidence of a positive association between women's empowerment and improved nutrition outcomes of women and their families[2] and that Education and women's knowledge of nutrition are key ingredients for a successful women's empowerment[3]. However, the evidence backing the effect of women's empowerment in agriculture on malnutrition appears to be context specific and results are inconsistent and therefore warrants more research. Women are central actors in achieving better household nutrition[4]. Aside from being child bearers and caregivers with a more direct influence on fetal and infant health, women choose to allocate more resources than men towards their family's health and nutrition[5]. However, given persistent gender inequalities in many developing countries, women often lack the autonomy and decision-					

making power within the household to make key decisions leading to better health and nutritional outcomes[6], and the resources with which to implement those decisions. Therefore, empowering women is increasingly recognized as a proper strategy to improve maternal and child health and nutrition.

In this activity, we plan to use radio as a tool for providing nutrition, and health messages to empower women in remote or disadvantaged communities of northern Ghana. Empowerment is essentially a transition from a position of enforced powerlessness to one of power (ability to make decisions affecting oneself). One method of achieving women's empowerment is through mass communication and propaganda. Using radio as a tool of communication is innovative, low-tech, inexpensive and culturally appropriate to citizens of northern Ghana. Community Radio (CR) plays an important role in the lives of women as it creates awareness, provides information and education, improves their skills and on the whole, it promotes social, cultural, political and economic development or empowerment of women[7]. Radio has a wide diffusion and usually broadcasts in the local language. As a result of these attributes, it can be used as an effective community outreach campaign tool for women empowerment.

2. Objectives

2.1 To engage communities via radio phone-in and radio spots to sensitize the public on the link between women's empowerment and improved nutrition outcomes and agricultural productivity

2.2 To empower mothers with knowledge and skills that promote appropriate infant and young child feeding practices through radio discussions

2.3 To positively change knowledge, beliefs and attitudes of residents in communities with respect to the role of women empowerment in agricultural, nutritional and public health practices and services

2.4 To assess the effectiveness of message delivery through community radio messages delivered by community health workers (CHWs) or agricultural extension agents (AEAs)

3. Research questions

3.1 Can community radio improve women's empowerment for improved healthy feeding practices, nutritional status and increased agricultural productivity?

4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)

4.1 In terms of the program design, formative research will be conducted using key informant interviews and focus group discussions to identify general feeding and agricultural practices, and their knowledge, beliefs and attitudes with regards to recommended practices that the radio program will be highlighted.

Then we will have a design workshop to identify topics, plan the drama series, and discuss them. Community sensitization will be undertaken with assistance from drama groups on women's empowerment in agriculture and its importance for improved nutrition and agricultural productivity. Interactive talk shows on selected topics like women empowerment, innovative farming systems and consumption of available nutrient-rich foods will be the focus of the intervention.

Social marketing theory will be used to guide the intervention. Social marketing involves the increase in the acceptability of an idea or practice and relies heavily on traditional marketing strategies. Constructs of social marketing will be used to increase knowledge and attitudes of nutrition, agricultural and public health practices.

The intervention duration will be 6 months in the intervention districts. Mothers with children aged 6-18 months will be recruited and followed up until end line data are collected.

A total of 25 clusters will be selected from the intervention study area and another 25 clusters from the control study area. In each cluster, 12 households representing 12 study participants will be selected for the study.

Women's empowerment will be measured using the Women's Empowerment in Agriculture Index (WEAI) [8](Alkire et al., 2013). Infant and young child feeding (IYCF) practices will be measured using

maternal recall of practices related to breastfeeding and complementary feeding using eight IYCF indicators recommended by the WHO2 [9](WHO, 2008).
The effectiveness of the use of radio as a tool for empowering women to improve nutrition and increased agricultural productivity will be evaluated in a cluster non- randomized controlled trial. Two cross-sectional surveys will be conducted pre- and post-intervention. Communities will form the units of randomization for the trial, while children and their parents within the communities will form units of observation.
Baseline differences between the intervention groups will be assessed using ANOVA test (for continuous variables) or Chi-square test (for categorical variables). For impact analyses, the difference-in-difference (DID) impact estimates using fixed-effects regression models that assesses differences in changes over time between the two intervention groups and the control group [10](Gertler et al., 2011) will be applied to adjust for geographic clustering, infant age, gender and variables that will be significantly different between groups at baseline.

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Anthropometric data (linear growth as length-for-age Z-scores) and 24-hour dietary recall will be used for nutritional assessment; The primary outcomes of the intervention will be linear growth as assessed by mean change in length -for age (LAZ), women's empowerment in agriculture and mothers' level of knowledge and practice of recommended feeding and health practices **Secondary outcomes** Secondary outcomes will include: ✓ Mean change in weight and weight-for-length Z-scores (WLZ) ✓ Proportion of children consuming foods from 4 or more food groups ✓ Proportion of children consuming the recommended number of semi-solid/soft meals and snacks per day ✓ Proportion of children meeting minimum acceptable diet	Mahama Saaka/UDS

6. Milestones		
Deliverables	Means of verification	Date
6.1 Full study protocol developed	Study protocol	Aug. 2018
6.2 Baseline and follow-up surveys data	Report submitted and data upload on Dataverse	Dec. 2018
6.3 Airing of women's empowerment in agriculture advocacy and nutrition messages on 5 community radios	Progress reports on scheduled activities	Mar. 2019
6.4 The following articles will be published Assessment of Women's Empowerment in Agriculture Index [WEAI] and its relationship to production diversity, dietary diversity, child care practices, maternal and child nutritional outcomes	Article available online	Dec. 2019

7. Sustainable intensification indicators	
7.4 Social	✓ Gender equity in food production at the community level ✓ Level of public awareness on the role of women's decision-making power (women's empowerment) for improved nutrition and agriculture at individual level

	Number of functional community-based partnerships established to exchange knowledge and information on nutrition, agriculture and facilitate community dialogue at community level
7.5 Human	✓ Number of households reached by targeted radio messages on nutrition and agriculture at household level ✓ Percentage of women of childbearing age meeting minimal diet diversity score at individual level ✓ Prevalence of children aged 6-23 month receiving a minimum acceptable diet at individual level ✓ Number of households benefiting from nutrition intervention per district/region at household level ✓ Prevalence of stunting, wasting and underweight among children under 5 years at individual level ✓ Changes in nutritional knowledge and practices at individual level ✓ Access to foods (Dietary diversity score, Food consumption score) Uptake of essential nutrients at individual level

8. How will scaling be achieved?	
Scaling up nutrition and Agricultural interventions entails identifying those programs and practices of proven efficacy and applying management, communications, and monitoring principles and tools to expand the number of beneficiaries until everyone who requires the product or service is reached. During the process of scaling-up, given resource constraints and as a good management practice, it is often necessary to prioritize groups that have a more urgent need (in this case the most undernourished children). The findings could provide a framework for future media training of AEAs and CHWs in Ghana with the involvement of the Ghana Health Service. Activities may also help boost women's self-confidence, generate awareness about food production, child feeding practices and hygiene on a wider scale.	
9. How are the activities in this protocol linked to those of others?	
This is a cross-cutting activity which seeks among others to promote the women's empowerment in agricultural production and nutritional outcomes through radio and therefore has links with Sub-activity GH111A-1801 which will improve use of improved varieties and appropriate agronomic practices for increased yields in maize and legume production, Sub-activity GH112-1802 which targets improved feed for improved small ruminant production, Sub-activity GH121-1803 which seeks to engage ICT and GIS tools as a means to share information. The activity also seeks to address gender inequity relating to agricultural production by highlighting how gender-sensitive strategies and activities could help increase household food production and consumption.	

[1]Ruel, M.T., Alderman, H., 2013. Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? Lancet 382(9891), 536–551.
[2]United Nations, 2007. Report of the Secretary-General - Strengthening efforts to eradicate poverty and hunger, including through the global partnership for development United Nations New York.
[3]Scaling Up Nutrition, 2016. Empowering Women and Girls to Improve Nutrition: Building a Sisterhood of Success. In: Scaling Up Nutrition in Practice No. 6.
[4]Nisbett, N., van denBold, M., Gillespie, S., Menon, P., Davis, P., Roopnaraine, T., Kampman, H., Kohli, N., Singh, A., Warren, A., 2017. Community-level perceptions of drivers of change in nutrition: evidence from South Asia and sub-Saharan Africa Glob. Food Sec. Available at: http://dx.doi.org/10.1016/j.gfs.2017.01.006.
[5]World Bank, 2012. World Development Report 2012. The World Bank, Washington DC 20433.
[6]Cunningham, K., Ruel, M., Ferguson, E., Uauy, R., 2014. Women's empowerment and child nutritional status in South Asia: a synthesis of the literature. Matern. Child Nutr. 11, 1-19.
[7]Yalala Nirmala, 2015. The role of community radio in empowering women in India. Media Asia 42, 1-2, 41-46.
[8]Alkire, S., Meinzen-Dick, R., Peterman, A., Quisumbing, A.R., Seymour, G., Vaz, A., 2013. The Women's Empowerment in Agriculture Index. World Development 52, 71–91.

[9]WHO, 2008. Indicators for Assessing Infant and Young Child Feeding Practices. Part 2: Measurements. World Health Organization, Geneva.
[10]Gertler, P.J., Martinez, S., Premand, P., Rawlings, L.B., Vermeersch, C.M.J., 2011. Impact Evaluation in Practice. International Bank for Reconstruction and Development/The World Bank, Washington DC.

Sub-activity: GH212-1802: Effect of joint nutrition education and homestead vegetable production on the empowerment of women and household food security – Leader: Mahama Saaka

d. Research team

Name	Institution	Role
Mahama Saaka	UDS-Community Nutrition	Sub-activity lead
Jean Baptiste Tignegre	WorldVeg	Breeder to facilitate the production of dry season vegetables for households
WIAD Officer	Min. Food and Agric	Organize community durbars on food cooking demonstration and food preservation methods
Community Development Officer (To be identified)	Dept. of Community Development	Mobilization of community interest groups (e.g. women's groups)

e. Student(s)

Name	Institute	Degree	Start	End
1.				

f. Location(s)	25 communities in 5 districts (Savelugu, Tolon, Wa West, Nadowli and Kassena-Nankana) of Northern Ghana
g. Start	July 2018
h. End	December 2019

1. Justification

In the rural areas of Northern Ghana, inadequate intake of micro-nutrients is widespread primarily because staple diets are predominantly cereal-based, and intake of animal source foods is low. There is compelling evidence that malnutrition, particularly micronutrient deficiencies, contributes up to 35% of under-5 mortality and that malnutrition plays a similar role in maternal mortality [1](Black et al., 2008). More efforts to promote the production and consumption of nutrient-dense foods such as fruits and vegetables is, therefore, necessary to enhance dietary quality and ensure optimal growth, health and cognitive development in young children. Promotion of dietary diversity using locally available nutritious foods is an effective approach in low-income areas to improve the quality of young children's diet and, hence, their growth and development.
For poor households, vegetables and fruits are often the only sources of micronutrients in the family diet. Homestead production of fruits and vegetables provides the household with direct access to important nutrients that may not be readily available or within their economic reach.
Therefore, home gardening would be a good means to improve household food security.
Women are regarded as the primary producers of micronutrient-rich vegetables, the primary purchasers of food at the local markets, the primary preparers of food in the home, and the primary caregivers to children under 5 years old.
As part of undernutrition preventive interventions, homestead food production may ensure diversification of household diets by ensuring access and availability. They may as well provide additional benefits such as income and livelihood opportunities for resource-poor families and delivering a number of ecosystem services. However, reports from the dry season vegetable group showed that an improved vitamin A biofortified tomatoes

are not being patronized in the communities. Consequently, nutrition education activities are designed to target women to bring about the needed behaviour change to consume the produce. The Ministry of Agriculture will have the principal roles in this activity.		
2. Objectives		
2.1 To establish home gardens and evaluate their contribution to food and nutrition security among rural households		
3. Research questions		
3.1 Can homestead gardening improve the dietary quality and household food security and nutrition in rural households in Northern Ghana?		
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)		
4.1 Demographic, socio-economic and home garden information will be collected during household interviews using a structured questionnaire. An inventory of the cultivated plant species will be compiled and the number of individual plants of each species documented. Household food intake will be assessed by using a semi-quantitative method based on recall of foods consumed by the household during the 24 hours preceding of the survey from the household member who prepared the previous day's meals. The main independent variable will be the production and consumption of nutrient-dense foods. Household food security will be assessed by using food consumption score (FCS) and individual and household dietary diversity.		
5. Data to be collected and uploaded	Responsibility/Institute	
5.1 Access to nutritious foods, Dietary diversity, Food consumption score, Nutritional status (underweight, stunting, wasting), Uptake of essential nutrients, Food availability, Food accessibility, Food utilization, Food security composite index, Months of food insecurity and Household income and expenditure levels	Mahama Saaka (UDS)	
5.1 Study data	Mahama Saaka (UDS)	
5.2 Monitoring data	Mahama Saaka (UDS)	
5.3 Vegetable production	Mahama Saaka (UDS)	
6. Milestones		
Deliverables	Means of verification	Date
6.1 Functioning and productive gardens	Report on the establishment of community gardens	Mar. 2019
6.2 Nutrition education to targeted households	Technical report of intervention	May 2019
6.3 An article on Effect of joint nutrition education and homestead vegetable production on the empowerment of women and household food security	Article available online	Dec. 2019
7. Sustainable intensification indicators		

7.1 Social	Number of functional community-based partnerships established to exchange knowledge and information on nutrition, agriculture and facilitate community dialogue at community level
7.2 Human	✓ Number of households trained and engaged in home gardening at household level ✓ Percentage of women of childbearing age meeting minimal diet diversity score at individual level ✓ Prevalence of children aged 6-23 month receiving a minimum acceptable diet at individual level ✓ Number of households benefiting from nutrition intervention per district/region at household level ✓ Prevalence of stunting, wasting and underweight among children under 5 years at individual level ✓ Changes in nutritional knowledge and practices at individual level ✓ Access to foods (Dietary diversity score, Food consumption score) at household level ✓ Uptake of essential nutrients at individual level

8. How will scaling be achieved?	
Scaling up nutrition and agricultural interventions entails identifying those programs and practices of proven efficacy and applying management, communications, and monitoring principles and tools to expand the number of beneficiaries until everyone who requires the product or service is reached. During the process of scaling-up, it is often necessary to prioritize groups that have a more urgent need (in this case the most undernourished children). The main platforms through which nutrition interventions can be scaled up are health systems (where government is usually in the lead and the private sector also has a role) and food systems (where the private sector is most active, but government has an important role to play).	
9. How are the activities in this protocol linked to those of others?	
This activity has close links to Sub-activity GH111A-1804-2 which will Identify varieties of vegetable crop species with adaptation to Northern Ghana in the dry season, Sub-activity GH111A-1804-3 which seeks to improve the capacity of vegetable farmers on vegetable gardening and post-harvest techniques Targeting of nutrition-specific interventions will primarily be based on the vulnerability of households to food insecurity and high prevalence of undernutrition. Activities will be implemented in line with Africa RISING overall strategic partnerships and geographical targeting ensuring convergence of nutrition interventions with other interventions and stakeholder activities (including livestock and crops) to focus on the same locations with complementary services in order to increase the impact of each other's' actions.	
[1]Black, R.E., Allen, L.H., Bhutta, Z.A., Caulfield, L.E., de Onis, M., Ezzati, M., et al., 2008. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet 371, 243-260.	

10. Budget (USD)	
Budget Line	UDS
Personnel	4,000
Services	2,000
Supplies	1,496
Travel	1,200
Overhead (15%)	1,304
Total	**10,000**

Sub-activity: GH212-1803: An Evaluation of Using Mother Care Group Approach/Model in Improving Nutrition Behaviour - Leader: Mahama Saaka				
d. Research team				
Name	Institution	Role		
Mahama Saaka	UDS	Sub-activity leader		
Chrisantus Daari	GHS	Assists with training of women's groups, data collection and compilation of monthly reports on activities		
Glover	UDS	Social Scientist to assist with the conduct of a qualitative formative study on gender issues on nutrition at the community level		
Lawal Alhassan	GHS	Assists with training of women's groups, data collection and compilation of monthly reports on activities		
Khadija Wemah	GHS	Monitor sub-district field activities including delivery of nutrition education, mothers' group meetings and home visits		
e. Student(s)				
Name	Institute	Degree	Start	End
Richard Dogoli Nantanba	UDS, Dept. Nutritional Sciences	MPhil (Public Health Nutrition)	August 2018	December 2019
f. Location(s)	25 communities in 5 districts (Savelugu, Tolon, Wa West, Nadowli and Kassena-Nankana) of northern Ghana			
g. Start	August 2018			
h. End	March 2019			
1. Justification				
Improving the nutritional status of women and children in northern Ghana remains a high public health and development priority. Women's groups are emerging as platforms for delivering health- and nutrition-oriented programs and addressing gender and livelihoods challenges. Furthermore, available evidence suggests that women's group-based programs are the most successful in improving nutrition outcomes, especially for IYCF practices [1](Kumar et al., 2017). This activity, therefore, seeks to assess the nutritional and health impact of the Care Group model. The intervention focuses on promoting behaviour change through the Care Group model, which aims to create individual and community behaviour change in health, nutrition and hygiene. This model is chosen based on its success in other countries and its simple approach of messaging to mothers. Bringing women together in groups where they can share their experiences, gain access to resources				

and build knowledge, skills, and social networks is increasingly recognized as a potential strategy to empower women and may also be a way to improve maternal and child health and nutrition.
A Mother Care Group (MCG) comprises 10-15 Lead Mothers (LMs) who are community volunteers and grouped into a Household Caregiver Group. Trained Community Health Workers (CHWs) train the Lead Mothers initially in the overall MCG approach and other lessons that are grouped into thematic modules. The design of the modules and lessons are based on the formative research (using, e.g., the barrier analysis method). The barrier analysis is used to inform the types of practices, which need to change in order for communities to thrive.
Each group member is responsible for regularly visiting 10-15 of her neighbors, sharing what she has learned and facilitating behaviour change at the household level. Mother Care Group is expected to meet regularly over a four to six-week period. In addition, LMs are asked to conduct home visits to each of her 10-14 household caregivers at least once during that period. This is to reinforce the behavior promoted during the group session and to provide individually tailored counselling, which will meet a household caregiver's needs.
The CHWs facilitate all MCG meetings and are expected to supervise at least one Lead Mother from each MCG every month. Supervision consists of attending the Lead Mother's meeting, accompanying the LM on a household visit, reviewing her reporting forms, and providing feedback and support.

2. Objectives

2.1 To improve infant and young child feeding (IYCF) practices through mother group dynamics

2.2 To improve maternal nutrition through knowledge sharing Care Group Model

3. Research questions

3.1 How effective is the Care Group Model in improving maternal and child nutrition?

4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)

4.1 A pre-post evaluation design will be used to assess the intervention. At least 25 Care Groups will be formed across the 25 Africa RISING intervention communities. The groups will be led by 25 Community Health Workers (CHWs) and supported by 50 Care Group Volunteers (CGVs), to be selected by community members.
Nutrition behavior change topics in the context of women's groups will include dietary diversity, IYCF practices, sanitation and hygiene, and access to and utilization of health services. Promoting healthy behaviors and health care-seeking among women through group-based strategies is hypothesized to improve knowledge, motivation and social support for these behaviors and, in turn, lead to better household practices around diet, health, and hygiene, and ultimately better maternal and child nutrition outcomes.
The CGVs primary function is to visit households at least once a month and deliver key nutrition and health messages to promote behaviour change in the following areas:
a) IYCF (timely breastfeeding, exclusive breastfeeding, continued breastfeeding up to two years and appropriate complementary feeding practices).
b) Nutrition and maternal care in pregnancy (importance of proper nutrition with the available resources and the importance of attending antenatal clinics).
c) Water, sanitation and hygiene (essential hygiene actions such as purification and storage of water, hand-washing and prevention and management of diarrhoea.

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Study data	Mahama Saaka/UDS

6. Milestones

Deliverables	Means of verification	Date

6.1 Formation and utilization of Mother Care Group (MCG) for delivery of health and nutrition messages in 25 intervention communities	Impact Evaluation report of intervention	Mar. 2019

7. Sustainable intensification indicators	
7.1 Social	✓ Number of mother care groups formed and trained at the community level ✓ Number of functional community-based partnerships established to exchange knowledge and information on nutrition, agriculture and facilitate community dialogue at the community level
7.2 Human	✓ Proportion of mothers having adequate knowledge of IYCF practices at individual level ✓ Percentage of women of childbearing age meeting minimal diet diversity score at individual level ✓ Prevalence of children aged 6-23 month receiving a minimum acceptable diet at individual level ✓ Number of households benefiting from nutrition intervention per district/region at household level ✓ Prevalence of stunting, wasting and underweight among children under 5 years at individual level ✓ Changes in nutritional knowledge and practices at individual level.

8. How will scaling be achieved?
Scaling up nutrition and Agricultural interventions entails identifying those programs and practices of proven efficacy and applying management, communications, and monitoring principles and tools to expand the number of beneficiaries until everyone who requires the product or service is reached. During the process of scale-up, given resource constraints and as a good management practice, it is often necessary to prioritize groups that have a more urgent need (in this case the most undernourished children). The main platforms through which nutrition interventions can be scaled up are health systems (where the government is usually in the lead and the private sector also has a role) and food systems (where the private sector is most active, but the government has an important role to play).
9. How are the activities in this protocol linked to those of others?
Activities will be implemented in line with the Africa RISING overall strategic partnerships and geographical targeting ensuring convergence of nutrition interventions with other interventions and stakeholder activities that seek to deliver useful messages to community groups (e.g. Sub-activity GH121-1803 which seeks to engage ICT and GIS tools as a means to share information on agriculture and nutrition.
[1]Kumar, N., Scott, S., Menon, P., Kannan, S., Cunningham, K., Tyagi, P., Wable, G., Raghunathan, K., Quisumbin, A., 2017. Pathways from women's group-based programs to nutrition change in South Asia: A conceptual framework and literature review. Global Food Security, Available at: https://doi.org/10.1016/j.gfs.2017.1011.1002.

10. Budget (USD)	
Budget Line	UDS
Personnel	4,000
Services	2,000
Supplies	1,496
Travel	1,200
Overhead (15%)	1,304
Total	**10,000**

2018 Africa RISING West Africa Activity Protocol – Outcome 3: GH311-18				
Outcome 3: Farmers and other value chain actors have greater and equitable access to production assets and markets (input and output) through enabling institutions and policies				
a. Output 3.1	Improved policies and institutional arrangements to increase participation of farm families, especially women and youth in the output and input markets and decision-making are developed.			
b. Activity 3.1.1	Identify constraints to and opportunities for improving access to the output and input markets by women and youth in the target area.			
c. Sub-activity GH311-18	Assess institutions enabling or constraining access to output and input markets by farm households (particularly youth and women) in Africa RISING intervention Regions of Ghana			
d. Research team				
Name	Institution	Role		
Charity Osei-Amponsah	CSIR-STEPRI	Sub-Activity leader		
Adams Abdulai	CSIR-STEPRI	Research Assistant (Agric economics)		
Nana Yamoah Asafu-Adjaye	CSIR-STEPRI	Research Assistant		
Maame Dokuaa A. A. Addo	CSIR-STEPRI	Research Assistant		
Bekele Kotu	IITA	Support for research design and conceptualization		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	Purposively selected towns in specific districts of the Upper West, Upper East, and Northern regions			
g. Start	August 2018			
h. End	August 2019			
1. Justification				
Enabling institutional contexts enhance the effectiveness of up-scaling initiatives by projects. The Africa RISING project intends to promote the use of validated technologies generated from previous research activities, it is, therefore, important to first understand the institutional landscape to unravel issues that enable and/or constrain access to output and input markets. This will generate insights for designing tailor-made scaling-up/out models that would respond effectively to helping smallholders overcome constraining market institutions for better adoption of promoted SI technologies.				
2. Objectives				

Assess institutions that enable or constrain access to output and input markets by women and youth in Northern Ghana.		
3. Research questions		
3.1 What attitudes to learning, new knowledge, and innovations are prevalent among smallholders for the creating output and input markets, and what incentives are in place to encourage their use? 3.2 What input and output market opportunities exist for smallholders, and how efficient are the value chains surrounding the livestock and maize, cowpea markets in the three northern regions of Ghana?		
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)		
Desk research, personal interviews, participatory rural appraisal, focus group discussion, validated with household surveys using semi-structured questionnaires. Data will be disaggregated based on youth, women and men.		
5. Data to be collected and uploaded	Responsibility/Institute	
5.1 Secondary and primary quantitative and qualitative data	Charity Osei-Amponash/CSIR-STEPRI	
6. Milestones		
Deliverables	Means of verification	Date
Dataset on the institutional landscape for access to output and input markets collected	Interview guides; tape recorded and transcribed information, pictures and videos, quantitative data sets compiled	Jan. 2019
Report on preliminary analysis of data collected	Submitted report	Apr. 2019
Report on the complete analysis of data collected, including lessons and recommendations of approaches to creating enabling institutions for access to output and input markets submitted	Submitted report	Aug. 2019
Paper article and policy brief published in International Journal of Agricultural Sustainability or Sustainability	Journal article and policy brief publications	Jul. 2020
7. Sustainable intensification indicators		
7.1 Productivity	How enabling market institutions have affected Production yields/ at farm household levels	
7.2 Environment	How input market institutions have affected ecological practices, crop-livestock integrated innovations/ at farm household levels	
7.3 Economic	Input and output market participation, agricultural income/ at district and farm household levels	
7.4 Social	Social cohesion- Participation in community activities; Level and reliability of social support/ community (town) and farm household levels	
7.5 Human	Capacity to experiment and innovate- Number of farmers experimenting and using the validated technologies/ community (town) and farm household levels	

8. How will scaling be achieved?
N/A
9. How are the activities in this protocol linked to those of others?
The activities in this protocol mainly focus on markets, institutions, policies and adoption of new SI technologies. These activities link directly to activities GH111-18 and GH112-18 which seek to generate new SI technologies and practices. The outlined activities will help to unravel insights on how access to input and output markets are achieved by women and youth.

10. Budget (USD)	
Budget Line	CSIR-STEPRI
Personnel	6,000
Services	1,500
Supplies	1,000
Capital	1,000
Travel	6,000
Overhead	2,500
Total	**18,000**

2018 Africa RISING West Africa Activity Protocol – Outcome 3: GH321-18				
Outcome 3: Farmers and other value chain actors have greater and equitable access to production assets and markets (input and output) through enabling institutions and policies.				
a. Output 3.2	Options to increase access to production assets and increase participation in decision-making by women, youth and other vulnerable groups.			
b. Activity 3.2.1	Identify constraints to and opportunities for increasing women and youth access to production assets/decision making in the target area.			
c. Sub-activity GH321-18	Analyze intra-household differences and decision-making for adoption.			
d. Research team				
Name	Institution	Role		
Jeroen Groot	WUR	Farming systems analysis (Activity Leader)		
Katrien Descheemaeker	WUR	Farming systems analysis		
Bekele Kotu	IITA	Economic analysis		
Gundula Fischer	IITA	Gender assessment		
e. Student(s)				
Name	Institute	Degree	Start	End
Mirja Michalscheck	WUR	PhD	2014	2018
f. Location(s)	Duko (Northern Region), Nyangua (Upper East Region), Zanko (Upper West Region)			
g. Start	September 2018			
h. End	October 2019			
1. Justification				

The second phase of Africa RISING is about scaling up 'successful technologies'. For scaling up it is important to know the target farms and farmers, since farming systems are diverse and not all technologies are equally suitable for each farm household and their household members. We know that different household members have different roles and interests (production orientation) as well as power positions (assertiveness). Interests and power positions, together, result in farm decisions. Together, all farm decisions result into one specific farm configuration (land and labor allocation, cropping pattern) per season. Each farm configuration is hence associated to a certain degree of satisfaction for each household member. A change in farm configuration may benefit one household member and adversely affect another. We currently do not understand well the intra-household trade-offs associated with alternative farm designs for sustainable intensification. This piece of information is an innovative and highly valuable addition to the exploration of technical possibilities (alternative farm configurations) as determined in the whole-farm model Farm DESIGN. Since Africa RISING wants especially women and children to benefit from their technologies (improved agronomic practices), we argue that a deeper look into the household is indispensable to understand scaling possibilities as well as possible impacts per technology.
2. Objectives
2.1 Identify roles and power positions in negotiations and discussions concerning crop allocation decisions
2.2 To verify the mechanisms of decision-making in relation to interests, power and satisfaction of actors
3. Research questions
3.1 What are the intra-household trade-offs associated with alternative farm designs for sustainable intensification?
3.2 Do different household members evaluate the different AR technology packages differently? If yes: on what aspects do perceptions differ? And what can be concluded for technology targeting/scaling?
3.3 How do female and male household members interact during a game-based discussion and negotiation?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
4.1 Individual (and separate) farmer interviews with minimum one female and one male adult per case study household (n=9 households). Method: a gaming approach with leaves or pebbles serving to express the degree of satisfaction (ranging from 0-10, 0= not satisfied; 10= highest satisfaction possible). The approach has been tested during a field visit in August 2016. 4.2 Serious gaming settings with groups and representatives to extract power positions, negotiation styles and mechanisms of decision-making.

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Per variable (e.g. land allocation to maize) we capture one 'range of values' (expressing satisfaction) per household member. The results of all household members will be 'pooled' in one Excel table and the results will jointly be presented in a line chart. Further visualizations may be added. Data for all variables, all households and household members will be made available to AR colleagues on Dataverse.	Mirja Michalscheck/WUR

6. Milestones		
Deliverables	Means of verification	Date
6.1 Journal article: Intra-household trade-offs among alternative farm designs for sustainable intensification	Submitted for publication	July 2018
6.2 Journal article: Game-based analysis of negotiation and decision-making within households	Submitted for publication	October 2018
6.3 Feedback to farmers, generalizable recommendations, policy briefs	Uploaded document by Jeroen Groot and Mirja Michalscheck	December 2018

7. Sustainable intensification indicators	
7.1 Social	Equity in interactions among household members and resulting decisions
7.2 Human	Interests, power and satisfaction with crop allocation decisions

8. How will scaling be achieved?
Existing typologies (e.g. Signorelli, 2016) may serve to broadly test the validity of identified intra-household patterns per farm type. Knowledge about intra-household differences (and trade-offs) may sensitize/improve ongoing scaling efforts, minimizing intra-household trade-offs.
9. How are the activities in this protocol linked to those of others?
Linked to protocols GH111A-18.

10. Estimated Budget (USD)	
Budget Line	WUR
Personnel	22,500
Services	2,500
Supplies	1,500
Capital	0
Travel	2,000
Overhead	3,375
Total	**31,875**

2018 Africa RISING West Africa Activity Protocol – Outcome 4: GH411-18		
Outcome 4: Effective partnerships are built with farmers, local communities, and research and development partners in the private and public sectors to ensure delivery and uptake at the scale of SI technologies, innovations and practices.		
a. Output 4.1	Alliances and effective partnerships developed between farmers, local communities, and research and development agents in the public and private sectors to enable the release, dissemination, and adoption of proven technologies and practices to scale.	
b. Activity 4.1.1	Conduct cost-benefit and gender analysis coupled with other socio-economic analyses to identify and quantify adoption constraints and opportunities for different farmer contexts.	
c. Sub-activity GH411-18	Predicting the adoption of sustainable agricultural practices in Sudan and Guinea Savanna agroecologies	
d. Research team		
Name	Institution	Role

Bekele Kotu	IITA	Economic analysis, Activity leader
Francis Muthoni	IITA	GIS analysis
Felix Badolo	ICRISAT	Economic analysis
Abdul Rahman Nurudeen	IITA	Cereal agronomy and plant nutrition
Shaibu Melon	IITA	Data analysis

e. Student(s)

Name	Institute	Degree	Start	End

f. Location(s)	Ghana: Northern Region, Upper West Region, and Upper East Region Mali: Koutiala and Bougouni districts
g. Start	July 2018
h. End	December 2019

1. Justification

The farming systems in Northern Ghana and Southern Mali are characterized by low productivity caused by the low use of improved agricultural technologies, low soil fertility, pest attacks, and low and unpredictable rainwater (Ellis-Jones et al., 2014[11], Aniah, et al., 2013[12], Ollenburger, et al., 2016[13]). The low productivity of crops, particularly the staple ones, has resulted in food insecurity and poverty among farming households (Mahama et al. 2017[14]; Kotu, et al 2017[15]). Several best fit technologies have been identified within Africa RISING including (among others): improved crop varieties, soil fertility improvement/management methods, and crop pest control methods. Studies indicate that some newly developed farming technologies and techniques are superior to existing practices and, if adopted, will improve the livelihood of smallholder farmers (Abdulai et al., 2017[16], Michalscheck et al.,

[11] Ellis-Jones J, Larbi A, Hoeschle-Zeledon I, Dugie I Y, Teli I A, Bauh S J, Kanton R A L, Kombiok J M, Kamara A Y, and Gyamfi I (2013). Sustainable intensification of cereal-based farming systems in Ghana's Guinea savannah: Constraints and opportunities identified with local communities. IITA Report. IITA, Ibadan, Nigeria.

[12] Aniah, P., Wedam, E., Pukunyiem, M., & Yinimi, G. (2013). Erosion and livelihood change in North East Ghana: A look into the bowl. International Journal of Sciences: Basic and Applied Research, 7(1), 28–35.

[13] Ollenburger, M. H., Descheemaeker, K., Crane, T.A., Sanogo, O.M., Giller, K. E., 2016. Waking the sleeping giant: Agricultural intensification, extensification or stagnation in Mali's Guinea Savannah. Agricultural Systems 148 (2016) 58–70.

[14] Mahama S, Oladele J, Larbi A, Hoeschle-Zeledon I. 2017. Household food insecurity, coping strategies, and nutritional status of pregnant women in rural areas of Northern Ghana. Food Sci Nutr. http://doi.org/10.1002/fsn3.506

[15] Kotu, B. H., Alene, A., Manyong, V., Hoeschle-Zeledon, I., & Larbi, A. (2017) Adoption and impacts of sustainable intensification practices in Ghana. International Journal of Agricultural Sustainability, 15 (5), 539-554, DOI: 10.1080/14735903.2017.1369619

[16] Abudulai, M., Kusi, F., Seini, S. S., Seidu, A., Nboyine, J. A., Larbi, A. 2017. Effect of planting date, cultivar and insecticide spray application for the management of insect pests of cowpea in northern Ghana. Crop Protection, 100:168-176.

2018[17]; Buah et al., 2013[18]; Kanton et al., 2013[19]). Farmers have also started using some of the technologies promoted in their areas. However, there has been little effort to predict the adoption and diffusion of the new technologies among the smallholder farmers in the areas where they have been experimented and beyond. Prediction of adoption of the technologies will be useful for improved evaluation of potential investments in agricultural research, development and extension (Alston et al., 1995[20]) or policy adjustments (Pannell et al., 2006[21]) that depend crucially on assumptions about rates of adoption of new practices. Therefore, this study will assess the potential maximum adoption rate and the time taken to reach that level by considering the characteristics of the technologies and the smallholder farmers' population.
2. Objectives
2.1 To predict the adoption of sustainable intensification technologies promoted by Africa RISING project in Northern Ghana
2.2 Identify and display potential locations for the scaling of the technologies
3. Research questions
3.1 How much is the peak and speed of adoption for various technologies promoted by Africa RISING project in northern Ghana and southern Mali
3.2 What are the most important factors determining the peak and speed of adoption among various technologies?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
We will consider multiple practices such as cropping system diversification (spatial as well as temporal), soil fertility management practices, improved varieties, and other best fit technologies to be identified. Data will be collected from secondary sources (such as previous surveys and literature) and primary sources. For primary data, we will conduct focus group discussions and key informant interviews. Data will be collected on key variables on four major drivers of adoption: 1) relative advantage for the population; 2) relative advantage of the practice; 3) learnability characteristics of the practice; 4) population-specific influences on the ability to learn about the practice. The Adoption and Diffusion Outcome Prediction Tool (ADOPT) will be used for predicting adoption (Kuehne et al., 2017[22]). GIS will be used to identify and display areas of potential scaling.

[17] Michalscheck M., Groot J.C.J., Kotu B., Hoeschle-Zeledon I., Kuivanen K., Descheemaeker K., Tittonell P. (2017). Model results versus farmer realities: Operationalizing diversity within and among smallholder farm systems for a nuanced impact assessment of technology packages. Agricultural Systems 162: 164–178

[18] Buah S J, Larbi A and I. Hoeschle-Zeledon (2013) Grain yield responses of maize to nitrogen fertilizer rate in the Guinea savannah. Paper presented at the ' 6th International Nitrogen Conference', Kampala, Uganda, 18-22 November, 2013.

[19] Kanton R A L, Larbi, A., Buah, S. S., Kombiok, J. M., Ansoba, E., Aungre, P.A. Asungre, Lamin, S., Prasad, P.V. V. (2013). Effect of nitrogen fertilizer on growth and yield of maize varieties with different maturities in a dry agro-ecology of northern Ghana. Accepted for presentation at the Annual General Meeting of the Crop Science Society of America (CSSA)/ Soil Science Society of America (SSSA) and the American Society of Agronomy (ASA), Tampa, Florida, 3 – 7th November 2013.

[20] Alston, J., Norton, G., Pardey, P., 1995. Science under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting. Cornell University Press, Ithaca, NY.

[21] Pannell, D., Marshall, G., Barr, N., Curtis, A., Vanclay, F., Wilkinson, R., 2006. Understanding and promoting adoption of conservation technologies by rural landholders. Australian Journal of Experimental Agriculture, 46, 1407–1424.

[22] Kuehne, G., Llewellyn, R., Pannell, D.J., Wilkinson, R., Dolling, P., Ouzman, J., Ewing, M. 2017. Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy Agricultural Systems 156 (2017) 115–125

5. Data to be collected and uploaded		Responsibility/Institute
5.1 The data set will be uploaded to the repository of the program (Dataverse)		IITA
6. Milestones		
Deliverables	Means of verification	Date
6.1. Dataset of farmers' assessments of technologies	Dataverse	Jun. 2019
6.2. Publication	Journal	Dec. 2019
7. Sustainable intensification indicators		
7.1 Productivity	Yield (grain, biomass)	
7.2 Environmental	Environmental impact, time to environmental impact	
7.3 Economic	Profit in the year that it is used, profit in future time, time of profit to be realized	
7.4 Social	Social cohesion (Participation in a collective action group)	
7.5 Human		

8. How will scaling be achieved?
This research takes the outputs of previous bio-physical studies as input.
9. How are the activities in this protocol linked to those of others?

Budget Line	IITA
Personnel	3,500
Services	0
Supplies	500
Capital	0
Travel	3,000
Overhead	0
Total	**7,000**

2018 Africa RISING West Africa Activity Protocol- Outcome 4: GH412-18		
Outcome 4: Effective partnerships are built with farmers, local communities, and research and development partners in the private and public sectors to ensure delivery and uptake at the scale of SI technologies, innovations and practices.		
a. Output 4.1	Understanding the social, economic, and institutional constraints to and opportunities for technology adoption from different farm typologies improved	
b. Activity 4.1.2	Map and assess relevant stakeholders to establish a dialogue for the exploration of mutual synergies for scaling delivery of validated technologies	
c. Sub-activity Gh412-18	Identify and assess delivery pathways to leverage and engage with existent initiatives including Government extension systems	
d. Research team		
Name	Institution	Role

Charity Osei-Amponsah	CSIR-STEPRI	Sub-activity leader		
Adams Abdulai	CSIR-STEPRI	Research Assistant (Agric. economics)		
Nana Yamoah Asafu-Adjaye	CSIR-STEPRI	Research Assistant		
Maame Dokuaa A. A. Addo	CSIR-STEPRI	Research Assistant		
Bekele Kotu	IITA	Support for research design and conceptualization		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	Upper West, Upper East, and Northern regions			
g. Start	August 2018			
h. End	August 2019			
1. Justification				
Lessons can be learned from existing initiatives, as well as tried and tested technology delivery pathways. The Africa RISING project intends to promote the use of validated technologies generated from previous research activities. It is, therefore, important to first understand the delivery pathways that are existing and how the project could engage with such initiatives for effective up-scaling approaches.				
2. Objectives				
Identify and assess delivery pathways of SI technologies to leverage and engage with existent initiatives on SI, including Government extension systems				
3. Research questions				
What organizational opportunities for SI delivery (extension and extension services; R&D; NGOs) exist and how effective are they in promoting SI practices and access to new knowledge and innovation by farmers? How can these be strengthened or taken advantage of in the implementation of other SI interventions?				
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)				
Desk research, personal interviews, participatory rural appraisal, focus group discussion, validated with household surveys using semi-structured questionnaires.				
5. Data to be collected and uploaded	Responsibility/Institute			
5.1 Secondary and primary quantitative and qualitative data	Charity Osei-Amponsah/CSIR-STEPRI			
6. Milestones				
Deliverables	Means of verification	Date		
Dataset on existing SI initiatives and technology delivery pathways	Interview guides; tape recorded and transcribed information, pictures and videos, quantitative data sets compiled	Jan. 2019		

Report on preliminary analysis of data collected	Report submitted	Apr. 2019
Report on the complete analysis of data collected	Report submitted	Aug. 2019
Paper article and policy brief published	Journal article and policy brief publications	Jul. 2020
7. Sustainable intensification indicators		
7.1 Environmental	Ecological practices, crop-livestock integrated innovations/ at farm household level	
7.2 Economic	Profitability of agricultural activities related to increased dissemination and adoption of SI technologies at the community level	
7.3 Social	Social cohesion- types of interaction between proponents of SI technologies suppliers and users at community levels	
7.4 Human	Capacity to experiment and innovate- the number of farmers experimenting and using the validated technologies/ at farm household level	

8. How will scaling be achieved?
N/A
9. How are the activities in this protocol linked to those of others?
The activities in this protocol mainly focus on markets, institutions, policies and adoption of new SI technologies. These activities link directly to GH111-18, GH112-18, GH113-18 and GH121-18, which seek to generate new SI technologies and practices. The proposed activities will help to unravel insights on how the generated technologies and practices are delivered and with what level adoption rate by farmers.

10. Budget (USD)	
Budget Line (USD)	CSIR-STEPRI
Personnel	7,250
Services	2,000
Supplies	2,000
Capital	2,000
Travel- STEPRI	6,000
Overhead cost (15%)	2850
Total STEPRI	**22,000**
Travel IITA	3,000
Total	**25,000**

2018 Africa RISING West Africa Activity Protocol – Outcome GH421-18				
Outcome 4: Effective partnerships are built with farmers, local communities, and research and development partners in the private and public sectors to ensure delivery and uptake at the scale of SI technologies, innovations and practices.				
a. Output 4.2	Gender-sensitive decision support tools to assess technology-associated risks and opportunities are available for use by project partners.			
b. Activity 4.2.1	Identify and communicate gender-sensitive decision support tools in the context of different farm typologies.			
c. Sub-activity: GH421-18	Dissemination of gender-sensitive technology assessment tools to project partners.			
d. Research team				
Name	Institution	Role		
Gundula Fischer	IITA	Social scientist, gender expert		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	Ghana and Mali (as well as all other Africa RISING countries)			
g. Start	October 2018			
h. End	December 2018			
1. Justification				
In 2017 the Africa RISING gender team developed participatory tools for the gender-sensitive assessment of the interaction of agricultural technologies with a variety of social, economic and other factors. The three most important tools are activity profiles (focusing on shifts in labor time and burden), matrix scoring (exploring changes in all SI indicator domains) and linkage diagrams (as an open tool to capture farmers' views without predefined foci). These tools were included in a gender training manual and disseminated to project partners in four training sessions in Mali, Ghana, Tanzania and Malawi in 2017. The final version of the manual will be available on CGSpace in 2018.				
2. Objectives				
2.1 To provide project partners with gender-sensitive technology assessment tools in the context of participatory farming systems and action research.				
3. Research questions				
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)				
5. Data to be collected and uploaded			Responsibility/Institute	
5.1 The "Gender Analysis in Agriculture" manual containing the tools will be uploaded to CGSpace accompanied by a blog on AR News to draw attention to it.			G. Fischer/IITA	
6. Milestones				
Deliverables	Means of verification		Date	
6.1. Manual uploaded	CGSpace		Dec. 2018	
6.2. Blog	AR News		Dec. 2018	

2018 Africa RISING West Africa Activity Protocol – Outcome 4: GH431-18				
Outcome 4	Effective partnerships are built with farmers, local communities, and research and development partners in the private and public sectors to ensure delivery and uptake at the scale of SI technologies, innovations and practices are built.			
a. Output 4.3	A framework for monitoring and evaluating technology adoption, and technology-associated risk accessible to the project team and scaling partners			
b. Activity 4.3.1	Monitor and modify the progress of the technology adoption process towards scaling			
c. Sub-activity GH431-18	Matching agricultural technologies to farms and their context			
d. Research team				
Name	Institution	Role		
Jeroen Groot	WUR	Farming systems analysis (Activity Leader)		
Francis Muthoni	IITA	GIS specialist		
Beliyou Haile	IFPRI	Economic analysis		
Lieven Claessens	IITA	Farming systems analysis		
Carlo Azzarri	IFPRI	Economic analysis		
e. Student(s)				
Name	Institute	Degree	Start	End
Vacancy	WUR	MSc	08/2018	06/2019
f. Location(s)	Duko (Northern Region), Nyangua (Upper East Region), Zanko (Upper West Region)			
g. Start	September 2018			
h. End	October 2019			

1. Justification

Increasingly, mobile phones and other ICT services are used to provide information and advice to farmers to facilitate learning, but support to targeting and scaling of agricultural technologies through ICT tools is scarce. ICT-based targeting and scaling approaches should not be considered a silver bullet, although they can increase the reach and reduce the costs of technology dissemination compared to traditional village extension services.

Sophisticated models of technology integration in farming activities exist, but they are often very data-intensive and do not extend beyond the farm level. Muthoni et al. (2017) utilized spatially-gridded biophysical and socio-economic layers to generate what they called “sustainable recommendation domains” (SRDs) that could be targeted for scaling specific technologies. The effectiveness of the suitability assessment can be further refined as long as the features of individual farms are considered and directly related to technology characteristics during the targeting phase. Innovations in coupling knowledge among site characteristics, household features and technology attributes with the SRDs is needed to guide spatial targeting of suitable technologies.

The FarmMATCH approach explicitly tries to fill this knowledge gap, facilitating the matching between agricultural technologies to farms and their context. It contains 1) a learning and matching algorithm that identifies the most suitable and promising technologies for different farm types, and 2) a data mining and signaling algorithm that identifies hotspots of the suitability of technologies and potential adopters. The matching algorithm combines contextual, farm and technology characteristics to create a ranking of the suitability and adoption probability of available innovations.

2. Objectives		
2.1 To develop a prototype of a targeting approach for farm technologies and techniques for farms in Northern Ghana.		
2.2 To train and validate the targeting algorithm with on-farm collected data.		
3. Research questions		
3.1 How can scaling approaches supported by defined recommendation domains be further refined for diverse farm households?		
3.2 What is the efficiency of Bayesian matching algorithms for the effective and rapid generation of lists of suitable technologies for diverse farm households?		
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)		
4.1 Data collection: GIS and GARBES databases for intervention areas in Northern Ghana will be used to select 1 km^2 grid cells with surveyed households. A minimal set of supplementary data on farm and household features and on-farm technologies and practices may be collected. 4.2 We select 15-30 grid cells of 1 km^2 from the three Northern regions of Ghana (NR, UER, UWR), so 5-10 cells per region. These cells differ in biophysical conditions (soil, rainfall, etc.) and socio-economic circumstances (e.g. distance to market). Moreover, within these cells we have at least 10 households sampled within the GARBES database collected by IFPRI; if this is not the case then additional data collection is required. In total ca. 300 farms will be included. There should also be diversity among the sampled households in the grid cell. For each household, we analyze in particular the main, easy to collect farm and household features (size, objectives, livestock, crop number, % off-farm income, etc.) and relate these to the farm practices and project-proposed technologies and techniques. The matching algorithm combines the GIS-derived data on biophysical conditions and socio-economic context circumstances with the farm features, to estimate the probability of use of the various technologies and techniques. The data set will be divided between a training set (n=200-240) and a testing set (n=60-100).		
5. Data to be collected and uploaded	Responsibility/Institute	
5.1 Data for all farm-households and algorithms will be made available to AR colleagues on Dataverse.	Jeroen Groot/WUR	
6. Milestones		
Deliverables	Means of verification	Date
6.1 MSc thesis and draft journal article: Matching agricultural technologies to farms and their biophysical and socio-economic context in Northern Ghana	Report uploaded	Jul. 2019
6.2 Blog on the potential of the concept and algorithm for scaling	Published on Africa RISING website	Aug. 2019
7. Sustainable intensification indicators		
7.1 Social	Equitable access to suitable technologies at scale	

8. How will scaling be achieved?
The modelling results will be discussed at farmer meetings. Findings will be shared and published.
9. How are the activities in this protocol linked to those of others?
The activity is linked to GH111A, GH111B, GH112 GH121-18, GH122-, GH131

10. Budget (USD	
Budget Line	WUR
Personnel	5,000
Services	1,000
Supplies	700
Capital	0
Travel	1,250
Overhead	750
Total	**8,700**

Consolidated budget

Activity	Leader	IITA	ILRI	IWMI	CIAT	WorldVeg	WUR	STEPPRI	UDS (Health Services)	KNUST	Total
Outcome 1: Farmers and farming communities in the project area are practicing more productive, resilient, profitable and sustainably intensified crop-livestock systems linked to markets.											
GH111A-18: Test, disseminate and adapt crop, livestock and integrated crop-livestock technologies and practices to increase and sustain the productivity of smallholder crop-livestock farming systems	IITA	251,350[1]				50,000					301,350
GH111B- 18: Test a combination of climate-smart crop varieties and agronomic practices to increase and sustain food and feed production	IITA	15,000									15,000
GH112 Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.											
GH112-1801: Efficient feed utilization through improved feed troughs	ILRI		70,000								70,000
GH112-1802: Feed-health interventions for improved small ruminant production	ILRI		20,000								20,000
GH121-18 Roll out soil and water conservation measures in selected farming systems to demonstrate their role towards in-situ moisture capture and storage, erosion reduction and climate risk adaptation	IITA	25,700			2,300					24,000	52,000
GH122-18 Research after agricultural water management under rainfed and irrigation conditions to improve water productivity in integrated crop-livestock systems of northern Ghana											

GH122-1801: Determining appropriate water scheduling methods for enhanced crop and water productivity in dry season vegetable production	IWMI			99,389							99,389
GH122-1802: Assess economic feasibility and farmers' views on the wetting front detector (WFD) irrigation scheduling tool for dry season vegetable production system in two communities (Nyangua and Tekuru), Upper East Region of Ghana											
GH133-18: Demonstrate small-scale maize shelling machines to smallholders and other stakeholders to reduce drudgery and labor requirements	IITA	5,000									5,000
Outcome 2: More farmers and farm families in the intervention communities are adopting technologies and practices to improve nutrition, food and feed safety, post-harvest handling and value addition.											
GH211-18: Nutrition-sensitive agriculture: analyzing relations among indicators of human and environmental health for smallholder households as affected by sustainable farm production and dietary diversity	WUR						8,700				8,700
GH212-1801: Using the Power of Radio to Promote women's empowerment for improved agricultural productivity and nutrition outcomes	UDS								25,000		25,000
GH212-1802: Effect of joint nutrition education and homestead vegetable production on empowerment of women and household food security	UDS								10,000		10,000

GH212-1803: An Evaluation of Using Mother Care Group Approach/Model in Improving Nutrition Behaviors	UDS								10,000		10,000
Outcome 3: Farmers and other value chain actors have greater and equitable access to production assets and markets (input and output) through enabling institutions and policies											
GH 311: Assess institutions enabling or constraining access to output and input markets by farm households (particularly youth and women) in Africa RISING intervention Regions of Ghana	STEPRI							18,000			18,000
GH321: Analyze intra-household differences and decision-making for adoption	WUR						31,785				3,1785
Outcome 4: Effective partnerships are built with farmers, local communities, and research and development partners in the private and public sectors to ensure delivery and uptake at the scale of SI technologies, innovations and practices.											
GH411: Predicting adoption of sustainable agricultural practices in Sudan and Guinea Savana agro-ecologies	IITA	7,000									7,000
GH412: Identify and assess delivery pathways to leverage and engage with existent initiatives including Government extension systems	STEPRI	3,000						22,000			25,000
GH431: Matching agricultural technologies to farms and their context	WUR						8,700				8,700
Grand total		297,850	90,000	99,389	2,300	50,000	49,185	40,000	45,000	24,000	**706,924**

[1]Includes 9,200 for UDS.

Mali

Partners and their responsibilities

Name	Acronym	Role/responsibility
Government Ministries & Entities		
Institute d'Economie Rurale	IER	Research on crops, livestock, natural resources management and nutrition. Capacity building to graduate students and national partners.
Regional Direction of Agriculture in Sikasso	DRA-Sikasso	Scaling out technologies, provision of secondary data on socio-economics
Academic/ National Research Institutions		
Wageningen University	WUR	Farming systems research, Postgraduate training program. Reports on typologies and farm characterization.
Institut Polytechnique Rural-De Formation et de Recherche Appliquee Katibougou	IPR-IFRA	Undergraduate and postgraduate training program
Non-Governmental organizations & research institutions		
Association Malienne d'Eveil et de Développement Durable	AMEDD	Community mobilization, assisting research activities and implementation of field trials in farmers' field. Facilitating multi-stakeholders interest group meetings. Hosting site coordinators. Capacity building to national partners. Leading implementation of scaling programs in phase II.
Fédération Nationale pour l'Agriculture Biologique et Équitable	FENABE	Community mobilization to facilitate implementation of field trials in farmers' field. Work in collaboration with AMEDD on multi-stakeholders' interest group meetings in Bougouni.
International Crops Research Institute for the Semi-Arid Tropics	ICRISAT	Mali project management. Consolidation of work plans, technical and financial reports. Activity coordination. Research on crops, natural resources management, socio-economics and scaling strategies. Capacity building to graduate students and national partners.
International Food Policy Research Institute	IFPRI	Support provision to monitoring and evaluation. Guidance on preparation of work plans to fit into FtF and other custom indicators.
International Institute of Tropical Agriculture	IITA	Overall project management and scientific guidance. Approval of work plans, evaluation of approved work plans and timely fund release. Organization of regional planning, review and scientific meetings and exchange visits.

International Livestock Research Institute	ILRI	Research on livestock and scaling out strategies. Capacity building to graduate students and national partners.
The World Vegetable Center	World Veg.	Research on vegetables, nutrition and scaling strategies. Capacity building to graduate students and national partners.

Summary

The Africa RISING West Africa (WA) project is being implemented by multi-disciplinary research teams and development partners from the public and private sectors in collaboration with farmers and community-based organizations in northern Ghana and southern Mali.

This document presents the work plan for the 2018-2019 research year for Mali. The work plan is mapped under the three Outcomes in the Phase 2 project logframe (See Table 1 below). A total of fifteen activity protocols are presented – 11 for Outcome 1; 1 for Outcomes 2; and 3 for Outcome 4.

Gender mainstreaming, capacity building and knowledge exchange and dissemination are embedded in all activity protocol. Linkages between activities are presented in each activity protocol. Publication of research results and better communication among research teams within and across countries will be a major focus.

Background

Phase 1 (1 October 2012 - 30 September 2016) and the first year of phase II (1 October 2016 – 30 September 2017) of the USAID-funded Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) project in West Africa (WA) was implemented in 25 intervention communities in northern Ghana and 9 villages in the Bougouni and Koutiala districts of the Sikasso Region in southern Mali under the *title 'Sustainable Intensification of Key Farming Systems in the Guinea-Sudano-Sahelian Zone of West Africa'*. Research activities under Phase 1 were organized around 3 research outputs (ROs), namely: 1) Situation analysis and program-wide synthesis (RO1); 2) Integrated Systems Improvement (RO2) and 3) Scaling and Delivery (RO3). Capacity building and gender were cross-cutting.

Phase 2 (1 October 2016 to 30 September 2021) of the WA project was launched in February 2017. The work plan is organized around 21 activities under 11 outputs to achieve four outcomes (Table 1). Implementation will be guided by achievements and lessons from Phase 1. There will, however, be a shift in approach from Research-for-Development(R-4-D) in Phase 1, to Research-in-Development (R-in-D) in Phase 2.

Technological packages and/or practices validated in Phase 1 (see Table 2) will be scaled out targeting agro-ecosystems and socio-economic circumstances defined by the sustainable intensification (SI) domains - productive, economic, social, human and environmental. Linkages will be established with research and development partners to undertake both generic and back-stopping research. The generic research aims at completing the loose ends of research on the SI innovations in Phase 2 plus any other emerging issues; the emphasis of the back-stopping research will be to address researchable issues emerging from the scaling-out of SI innovations with the development partners.

Table 1: List of validated technologies ready for promotion through development partners in Bougouni and Koutiala districts	
Broad category	Validated flagship technology
Introduction of new crops and varieties to overcome existing biotic and abiotic stresses and improve productivity per unit land area	High performing and dry season-adapted and farmer preferred vegetable varieties of okra (Konni), African eggplant (L10), Tomato variety (Rio Grande) Aflatoxin resistant groundnut, early-maturing groundnut Sorghum hybrids (Pablo, Fadda and Sewa), dual-purpose sorghum (Soubatimi, Tiandougou Coura, Jiguikala and Peke)
Agronomic practices to improve grain and fodder yield per unit land area, and improve soil nitrogen	Cereal-vegetable intercropping (tomato, pepper) Cereal-legume intercropping (groundnut) Dual-purpose food legumes
Integrated S*triga* and soil fertility management as a cost-effective approach to replenish soil fertility	Fertilizer micro-dosing, composting Cereal-vegetable intercropping (tomato, pepper) Cereal-legume intercropping (groundnut)
Improved livestock feeds and feeding, housing, health and breeding management packages	Stover quality improvement using feed chopper
Introduction of improved land and water management systems	Contour bunding associated with fast-growing tree species
Seed treatment	Apron Star 42WS

Planned work

The planned activities are presented in protocols. Activities under each protocol are aimed at achieving the outputs under the four outcomes in the project logframe.

Outcome 1:	Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.				
a. Output 1.1:	Research products for more productive, intensive, diverse, profitable and resilient crop (cereals, legumes, and vegetables); livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities.				
b. Activity 1.1.1:	Test a combination of climate-smart crop varieties and agronomic practices to increase and sustain food and feed production.				
c. Sub-activity MA1111-18:	Evaluating crop simulation models using different fertility sources and climate model outputs to improve the productivity of sorghum.				
d. Research team:					
Name	Institution	Role			
Akinseye Folorunso Mathew	ICRISAT	Postdoctoral fellow			
Birhanu Zemadim	ICRISAT	Activity coordinator			
Bouba Traore	ICRISAT	Postdoctoral fellow			
Badolo Felix	ICRISAT	Economist			
Oumar Samake	AMEDD	Community mobilization and multi-stakeholder interest group participation at farmers field day.			
Sidi Toure	ICRISAT	Field trial implementation in Samanko			
Karamoko Traore	ICRISAT	Field trial implementation in Bougouni			
Mahamadou Dicko	AMEDD	Field trial implementation in Koutiala			
e. Student(s)					
Name	Institute		Degree	Start	End
1. Madina Diacoumba	Université de Bamako		PhD	Jan. 2015	Jun. 2019
f. Location(s)	Bamako, Koutiala and Bougouni				
g. Start	April 2017				
h. End	March 2021				
1. Justification					
Inadequate soil fertility management and irregular rainfall distribution are the most important limiting factors for agricultural production in the Sudanian semi-arid farming systems. In the Sudanian region of Mali, sorghum is an important crop both for food and fodder uses, but limited use of inorganic fertilizer due to high market prices and limited access to credit has contributed to the decline in soil fertility. However, with large available organic resources from livestock and poultry manure, the study evaluates different fertilizer sources which combined both organic (cow and poultry manure) and inorganic fertilizer application on sorghum cultivars. The study demonstrated the benefit of manures from both ruminant and non-ruminants as alternate or complementary organic fertilizer in the fertilizer micro-dosing technology to increase sorghum yield productivity. Studies have shown that optimum productivity in crops may not be achieved without appropriate fertility management.					

Preliminary results obtained from the previous cropping season (2017) have demonstrated the benefit of manures from both ruminant and non-ruminants as alternate or complementary of inorganic fertilizer applied in micro-dosing technology resulting increase sorghum yield productivity. Also, the yield of sorghum cultivars (Fadda and Soumba) indicated a dual purpose for both food and fodder-use yields compared to Tieble cultivar. Our target is to increase productivity (grain and biomass) while the biomass production could further be used as a source of feed for the livestock and vice-versa. Furthermore, crop data, such as management, growth and yields as well as environmental condition (soil and weather data) collected from experimental sites across the rainfall gradients will be used to set up crop simulation models (APSIM and DSSAT) in combination with climate model outputs of the Coupled Model Inter-comparison Project Phase 5 (CMIP5) to assess climate change impacts on sorghum yields. Additionally, to evaluate the marginal cost-benefit of different fertilizer sources and varieties as adaptation options using contrasting GCMs scenarios. The analysis from both experiments and long-term simulation for current and future will help us to single out climate-smart fertilizer treatments application.
2. Objectives
2.1 To better understand the physiological functioning and yield potential of sorghum varieties under different fertilizer treatments (livestock manure and inorganic fertilizer) across different rainfall gradients and soil characterizations.
2.2 To evaluate the productivity of sorghum using the validated crop simulation models (APSIM and DSSAT) under current and future climate conditions based on observations and on Global Climate Models (GCMs) outputs.
2.3 Determine the marginal cost-benefit responses of different fertilizer sources based on current farming practices.
3. Research questions
3.1 How to increase sorghum productivity through optimizing fertilizer treatments (in agreement with climate-smart practices) and choosing the appropriate variety?
3.3 What is the sensitivity of the current sorghum yield to climate change using high-resolution climate models (GCMs) outputs?
3.4 What physiological and soil parameters are important to create a suitable crops system model?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
The protocol will be established in three locations (Samanko, Flola and M'pessoba respectively) in a 3 x 10 factorial experiment designed in a split plot design with 4 replications. The treatments include three (3) sorghum cultivars and ten (10) fertilizer applications including the control. The main plots include three varieties (Soumba, Tieble and Fadda). The sub-plot treatments include the use of synthetic fertilizer (DAP), manure from ruminants, poultry manure and the combination of the manures and NPK. The fertilizer treatments will be as follows: (i) DAP 100 kg/ha; (ii) NPK/DAP micro-dose (3g/hill), (iii) Cow manure (100g/hill), (iv) Cow manure (50g/hill) + poultry manure (50g/hill), (v) NPK/DAP (3g/hill) + Cow manure (100g/hill), (vi) Poultry manure (50g/hill), (vii) Poultry manure (100g/hill), (viii) Poultry manure (150g/hill), (ix) Poultry manure (100g/hill) + NPK/DAP micro-dose (3g), and (x) Control. Fertilizer application to be done at sowing. The main plot is 94 rows (70.5 m) x 11 m with a total area of 775.5 m^2, and the subplot is 6 rows (4.5 m) x 3 x 5 m long with a total area of 67.5 m^2. Net plot (harvested area) = 2 row x 5 m long = 7.5 m^2, and Gross plot = 50 m x 70.5 = 3525 m^2.

5. Data to be collected and uploaded	Responsibility/Institute

5.1 Agronomic (phenology, yield, yield components and for soil data (both physical and chemical properties)		ICRISAT
5.2 Economic data: the cost of seed, fertilizer, cow manure, poultry manure, and labour		ICRISAT
5.3 Climate data: daily rainfall, temperatures, solar radiation and relative humidity		ICRISAT
5.4 Farmers participations on field day		AMEDD
6. Milestones		
Deliverables	Means of verification	Date
6.1 Best fertilizer management practices that will contribute to increased sorghum productivity	Report included in the full report	Mar. 2018
6.2 At least 300 farmers will be reached via farmers field day	Report on farmers field day	Dec. 2018
6.3 Crop simulation Models (DSSAT and APSIM) outputs under different fertilizer scenarios to future climatic conditions	Technical report included in the final report	Mar. 2019
6.4 Economic cost and benefit analysis of sorghum under different fertilizer management application performed	Technical report included in the final report	Mar. 2019
6.5 Paper on Improving grain sorghum productivity in water-limited environments under climate change peer-reviewed journal	Field Crops Research Journal (published).	Mar. 2020
6.6 Technology handbook contribution: Technology 3: Sorghum-NPK-organic manure; Mali. Chapter 3: Integrated soil fertility management	West Africa technology handbook	Nov. 2018
7. Sustainable intensification indicators		
7.1 Productivity	Crop productivity (Yield kg/ha), Crop biomass productivity (residue production/ha/season), Variability of production (Coefficient of variability), distribution, etc., Cropping intensity (number of cropping seasons per year on a given plot (by crop), Plant population density (seeds/ha/season or seeds/ha/year) at plot level	
7.2 Environmental	Soil chemical quality (NPK, pH), OM at plot level	
7.3 Economic	Profitability (Net income) per ha	
7.4 Social	Equity (Rating of technologies /treatments locally will be determined during farmers field day and also analytical and modelling approaches at hectare level	
7.5 Human	N.A.	

8. How will scaling be achieved?
Scaling is achieved by developing and making available various fertility management options to the local NGOs, government extension system and other development actors in the region. The use of modelling approach helps to identify the potential yield advantages of varieties over a long-term climate change in different agroecological environments.
9. How are the activities in this protocol linked to those of others?
This activity (formerly MA1112-17) is linked to MA1112-18 that refers to understanding soil fertility management conditions in cereal cropping systems in southern Mali. Data from MA1112-18 will be used to develop scenarios and long-term forecasting of climate impact on farming systems in the modelling work of MA1111-18.

Outcome 1:	Farmers and farming communities in the project area are practicing more productive, resilient, profitable and sustainable intensified Crop-Livestock systems linked to markets.			
a. Output 1.1:	Research products for more productive, intensive, diverse, profitable and resilient crops (cereals, legumes, and vegetables); livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities.			
b. Activity 1.1.1:	To test a combination of climate-smart crop varieties and agronomic practices for increasing and sustaining food and feed production.			
c. Sub-activity MA1112-18:	Understanding soil fertility management in cereal cropping systems in southern Mali.			
d. Research team				
Name	Institution	Degree	Role	
Bouba Traore	ICRISAT	PhD	Postdoctoral fellow Activity coordinator Economic analysis Postdoctoral fellow	
Birhanu Zemadim	ICRISAT	PhD		
Felix Badolo	ICRISAT	PhD		
Akinseye Folorunso Mathew	ICRISAT	PhD		
e. Student(s)				
Name	Institute	Degree	Start	End
1. MSc student	IPR/IFRA	MSc	Jul. 2018	May 2019
f. Location(s)	Koutiala			
g. Start	April 2017			
h. End	March 2021			
1. Justification				

In Mali, since decades, stakeholders including farm households and scientist are increasingly recognizing soil nutrient depletion as one of the major constraints to sustainable agricultural development. Farming systems in the country are diverse due to climate, soils and production goals. Many complex factors are influencing the level of soil nutrient depletion that include nutrient management, regeneration and plant protection, livestock integration, soil and water conservation, biodiversity, agricultural policies and marketing structures. Farm households are confronted with deteriorating price relations between farm inputs and outputs resulting in a net exploitation of soil nutrients. Due to the prevailing poverty condition, farm households have limited options for investments in nutrient-adding or nutrient-saving technologies. Nowadays, this situation is worsening due to climate change and variability. Climate-smart technologies such as organic manure use and micro-dosing application have been implemented by various actors for soil nutrient depletion and climate change effect but still, there are lots of questions about the sustainability of this system. In this study, we will use NUTMON (NUTrient MONitoring) to monitor soil nutrient management across different farm typologies. It will include financial balancing under the current farming systems as well as the application of Climate Smart Technologies (CST) such as micro-dosing of mineral and organic fertilizer. A model will be used at plot scale with an extension to the household considering the population, expenses and assets from outside. In the end, NUTMON will be used as a decision support tool and will be presented to the extension workers as well as to policymakers. Composting technology using cotton stem will be developed and evaluated by field application strategies.
2. Objective: To optimize the nutrient flow and determine the efficiency of fertility management options.
2.1 Assessing nutrient flows and nutrient balance under different soil fertility conditions.
2.2 Exploring and testing promising nutrient management options.
2.3 Developing strategies for composting and improving nutrient use efficiency for sustainable soil fertility management.
3. Research questions
3.1 What are the determinants of soil fertility and nutrient balance under different soil fertility management conditions?
3.2 What are the farmers' adaptation option with regards to soil nutrient depletion conditions?
3.3 How can cotton stem be used as a source of diversification of composting as compared to sorghum or maize biomass?
3.4 What are the main constraints for composting and how can we reduce composting period? How can application techniques for compost improve soil fertility and crop productivity?
3.5 How can composting method improve product quality (NPK content, C/N ratio) and hence soil fertility?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.).
For mapping nutrient flow and balance, we will proceed with exhaustive diagnostic at farm scale involving 30 farmers from the three AR villages of Koutiala. The goal of the diagnostic phase is a participatory analysis of the current situation regarding soil nutrient depletion and economic performance. It entails a participatory rural appraisal (PRA), participatory resource flow mapping and quantifying the nutrient flows between soils, crops and livestock using NUTMON toolbox. Flows will be expressed in kilograms of N, P and K (nutrient flows), but also in monetary values (financial flows). The quantified nutrient flows explain which activities within a farm are nutrient consuming and which are accumulating nutrients, and how and when nutrients flow from one activity to another takes place. The quantifying financial flows will give insight into the profitability of activities (crops,

livestock, fishponds, compost heap and pits) and labour demands. Soil sampling and analysis provides essential information concerning the current nutrient status of the soils.

Exploration of promising nutrient management adaptation options will be done at farm level together with the farmer, and a process of participatory technology development will be organized with the objective of identifying technologies to address the problems identified in the diagnostic (see 4.1). Based on the diagnosis, farmers will be asked to prioritize technologies, which will be tested on-farm. In this phase, knowledge and experiences are used from both science-based and local knowledge systems in order to arrive at the most appropriate and consensus solutions.

For developing composting technologies, we will first use existing experience based on data collected during the previous year. Data collected under method 5.1; 5.2 for objective 4.1 will be used to consolidate experience on farmers composting management strategies. To reduce labour constraint, our approach will be based on heaps composting instead of compost pits. Two composting methods will be compared with cotton stems. Stems will be cut into pieces of 10 to 20 cm arranged under successive layers which will receive different doses of cattle manure and will be irrigated with water. Each compost heap will be covered with a plastic bag to limit evaporation and accelerate decomposition. In the different composting methods below, the rates of inputs are per hectare.

Composting with cotton stem

Compost 1: 1 t cotton stem +200 kg cattle manure
Compost 2: 2 t cotton stem +200 kg cattle manure

Field application of the two compost treatments will be done integrated with a recommended dose of mineral fertilizer. The experiments will be conducted in the technology parks as well as in the village with farmers. Each farmer will be experimenting with one of the two composting treatments.

Compost produced will be used in the micro-dosing system. The treatments include the following:

1. Zero (no application of compost and no mineral fertilizer)
2. Control practice 1 (Recommended mineral fertilizer)
3. Control practice 2 (Recommended mineral fertilizer micro-dosing)
4. Compost practice (farmers compost without cotton stem with spreading technique) and no fertilizer
5. Compost practice (farmers compost without cotton stem with micro-dosing technique) and no fertilizer
6. Compost practice (farmers compost without cotton stem with spreading technique) + Recommended mineral fertilizer
7. Compost practice (farmers compost without cotton stem with micro-dosing technique) + Recommended mineral fertilizer
8. Compost 1 with cotton stem (micro-dosing) + Recommended mineral fertilizer
9. Compost 1 with cotton stem (spreading)+ Recommended mineral fertilizer
10. Compost 2 with cotton stem (spreading) + Recommended mineral fertilizer
11. Compost 2 with cotton stem (micro-dosing) + Recommended mineral fertilizer

Recommended mineral fertilizer for sorghum is: 34 kg of N ha^{-1}, 34 kg of P ha^{-1} and 34 kg of K ha^{-1}

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Resource inventory, farm characterization, nutrient flow	ICRISAT
5.2 Soil physio-chemical analysis, Crop grain and biomass yield etc.	ICRISAT
5.4 For chemical characterization: pH (1: 2.5 H_2O), Total organic carbon, total NPK, calcium, magnesium, C/N	ICRISAT

ratio will be determined in the laboratory at maturation time of the compost.		
5.5 Crop yield across treatments; labour; economic cost etc	ICRISAT	
6. Milestones		
Deliverables	Means of verification	Date
6.1 Household level nutrient flow data.	Report included in the full report	Mar. 2019
6.2 Model result on nutrient flow characterized across farm typologies	Report included in the full report	Mar. 2019
6.3 Composting technology developed based on cotton stems; efficiency of compost application demonstrated	Report included in the full report	Dec. 2019
6.4 Integrated soil fertility management practices under different input and nutrient flow conditions	Journal article (Draft)	Jul. 2020
6.5 Technology handbook contribution: Technology 6: Compost making. Chapter 3: Integrated soil fertility management	West Africa technology handbook	Nov. 2018

7. Sustainable intensification indicators	
7.1 Productivity	Crop Productivity (Yield) at plot level, above-ground biomass (t/ha) at farm level
7.2 Environmental	Soil chemical quality (NPK, pH,) total organic matter at farm level
7.3 Economic	Profitability (Net income) at farm level
7.4 Social	Gender Equity
7.5 Human	The diversity of crops grown (% of all land) disaggregated by consumption versus sale at field level

8. How will scaling be achieved?
Developed technologies will be made available for scaling through training of farmers in different villages and of extension workers. Reports, technical documents and scientific papers developed with the activity will help to disseminate the technology widely.
9. How are the activities in this protocol linked to those of others?
This is farming system research including soil fertility management, crop management, socioeconomic analysis. Results can be used by other activities for further understanding of nutrient management under different soil fertility condition. It is therefore linked to MA1213-18 and MA1111-18.

Outcome 1:	Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.
a. Output 1.1:	Research products for more productive, intensive, diverse, profitable and resilient crop (cereals, legumes, and vegetables); livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities.
b. Activity 1.1.1:	Test a combination of climate-smart crop varieties and agronomic practices to increase and sustain food and feed production.
c. Sub-activity MA1113-18:	Evaluating improved dual purposes sorghum for crop-livestock integration and income generation in Sikasso Region.

d. Research team

Name	Institution	Role
Baloua Nebie	ICRISAT	Sorghum breeder and activity leader
Felix Badolo	ICRISAT	Economic assessment
Aboubacar Toure	ICRISAT	Scientific support
Mamourou Sidibe	ICRISAT	Field activities
Abdoulaye Diallo	IER	Field activities
Birhanu Zemadim	ICRISAT	Activity coordinator
Augustine Ayantunde	ILRI	Livestock feeding and performance data collection
Bougouna Sogoba	AMEDD	Data collection, farmers mobilization

e. Student(s)

Name	Institute	Degree	Start	End
To be identified	IPR/IFRA Katibougou	MSc	Jul. 2018	Mar. 2019
To be identified	IPR/IFRA Katibougou	Technician	Jul. 2018	Mar. 2019

f. Location(s)	Koutiala and Bougouni
g. Start	April 2017
h. End	March 2021

1. Justification

In Mali, sorghum and millet are used by farmers as staple food, especially in the rural areas. With the continuous increase of livestock coupled with the diminishing natural pastures, crop residues are playing an important role in feeding animals. Farmers are using landrace residues as fodder but the quantity and especially the quality of this feed is limited/poor. The stems are tall and hard due to high lignin content which negatively influences fodder digestibility. Also, most of improved Open Pollinated Varieties (OPVs) have low grain yield advantage compared to the local varieties. New varieties of sorghum combining grain yield (2t/ha), fodder yield (15 to 20 t/ha for fresh stover) and quality (green leaves until grain maturity) are now available (CEDEAO-UEMOA-CILSS, 2016[23]). These varieties were tested during phase one of Africa RISING program in different agro-ecological environments and seed production is going on with farmers' cooperatives. Therefore, this activity was proposed to evaluate the technologies in the four technology parks, farmers' fields and by linking farmers to seed cooperatives where they are available. With these varieties, farmers could make double gain and also increase their productivity and income. The proposed activity consists of a research and scaling component: The research component involves comparing improved multipurpose varieties to the local

[23] http://www.insah.org/doc/pdf/Catalogue_Regional_semences_vf_janv_2017.pdf

ones under different agronomic practices such as the type of fertilizer (chemical vs. organic manure). The scaling component involves scaling up of the use of varieties which were already tested in the target zones and officially registered into the national catalogue during the end of Africa RISING phase 1 period. The activity was conducted in 2017 and will be repeated in the 2018 agronomic season.	
2. Objectives	
2.1 Diversify sorghum varieties grown by farmers by introducing improved varieties.	
2.2 Enhance the availability of fodder through the use of dual/multi-purpose sorghum varieties in farmers cropping system.	
2.3 Identify the best variety (ies) and agronomic practice (s) for intensifying grain and fodder production under farmers' field conditions.	
3. Research questions.	
3.1 What are the best dual-purpose varieties preferred by farmers and adapted to their conditions?	
3.2 What is the best combination of variety and agronomic practice for better integration of crop and livestock?	
3.3 What option (variety x agronomic practice) is the most appropriate for farmers and in what condition?	
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)	
Three dual purpose sorghum varieties will be evaluated with 27 farmers from 9 villages (Bougouni and Koutiala circle). From each village, 3 farmers will be selected based on their commitment during the previous year. To enable the comparison between the improved varieties and the local one in the target zone, farmers preferred variety will be included as the local check in the trials. Depending on the availability, two types of fertilizers (organic manure = 5 tons/ha and DAP = 100 kg/ha) will be compared to farmers traditional practice (no fertilizer). The trial will also be implemented in the Technology parks at Koutiala and Bougouni with two replications in each trial. Evaluation by farmers will be done in the technology parks.	
Identification and training of farmers for the demonstration plots implementation. Men and women, animators, will be trained in trials implementation, post-harvest management of stover, etc. These farmers will thus train others in each locality.	
Evaluation of variety and hybrids by farmers (men and women) in their fields with farmers' practices and improved practices (plants density and fertilizer application). A total of 27 farmers (3 each from 9 villages) will conduct these trails.	
Data collection and analysis	
5. Data to be collected and uploaded	Responsibility/Institute
5.1 List of farmers implementing the activity and their diversity	Mamourou Sidibe/ICRISAT
5.2 Field characterization (soil type, cropping system, etc.)	Mamourou Sidibe/ICRISAT
5.3 Farmers preferences for varieties	Baloua Nebie/ICRISAT & A. Diallo/IER
5.4 Grain and stover yields	Baloua Nebie/ICRISAT
5.5 Stover biochemical composition	Baloua Nebie/ICRISAT
5.6 Plot survey (yields and input costs)	Felix Badolo/ICRISAT
5.7 Effect of fodder from different varieties on small ruminants' growth	Augustine Ayantunde/ILRI Hamidou Nantoume/IER
6. Milestones	

Deliverables	Means of verification	Date
6.1 Report on farmers training and trial establishment	Report included in the full report	Dec. 2018
6.2 Technology handbook contribution: (Sorghum hybrids) under chapter 1	WA technology handbook	Nov. 2018
6.3 Technology handbook contribution: Technology 3 (Dual purpose Sorghum hybrids) under chapter 1	WA technology handbook	Nov. 2018
6.4 Agronomic and biophysical dataset	Database shared	Mar. 2019
6.5 Map of trial locations on-farm/parks	Maps included in the full report	Jan. 2019
6.6 Report on farmers perception of varieties	Report	Mar. 2019
6.7 Scientific publication (with 2 years data)	Article	Jul. 2019

7. Sustainable intensification indicators	
7.1 Productivity	Yield/ha at plot and farm level
7.2 Environmental	
7.3 Economic	Net income/ha at plot and farm level
7.4 Social	Farmers' preferences per gender
7.5 Human	

8. How will scaling be achieved?
Farmers will be exposed to improved dual-purpose sorghum with different agronomic practices to allow them comparing the new technologies to their own ones. Most of the fields will be near the road or public places and plots will be labelled with key information to reach an important number of farmers. The same technologies will be implemented in the technology parks at Bougouni and Koutiala districts. Among the evaluators, we have a farmers' association which is producing milk in Koutiala district for selling. Some farmers of this association started, in 2015, using improved sorghum varieties stover for livestock feeding. The number of farmers using improved dual-purpose sorghum will be increased. Farmers from each village will be invited for field visit and extension service of agriculture in the different zones, rural radios will be also engaged for large-scale communication. Farmers Seed cooperatives are involved in the implementation of the activities so that they can produce seed for themselves and for other farmers who will look for a given variety.
9. How are the activities in this protocol linked to those of others?
Dual purpose sorghum trials with farmers will provide farmers with quality stover for their animals. This activity is focused on increasing yield and crop-livestock integration (dual-purpose sorghum). It is therefore linked to MA1121-18 and MA1122-18. The effect of the stover for each dual-purpose sorghum variety included in the trials will be evaluated on small ruminant performances. The cost-benefit analysis of dual-purpose sorghum and type of fertilizers will also be conducted.

Outcome 1:	Farmers and farming communities in the project area are practising more productive, resilient, profitable and sustainably intensified crop-livestock systems linked to markets.			
a. Output: 1.1:	Research will identify more productive, intensive, diverse, profitable and resilient crops (cereals, legumes, vegetables), livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems and will disseminate these to the farmers through development partners in the intervention communities.			
b. Activity 1.1.1:	Test a combination of climate-smart crop varieties and agronomic practices to increase and sustain food and feed production.			
c. Sub-activity MA1114-18:	Evaluating promising technologies tested over the past two years (2016-2017) for performance and profitability to intensify vegetable production under rainfed and dry seasons.			
d. Research team				
Name	Institution	Role		
Jean-Baptiste Tignegre	WorldVeg	Sub-activity leader: design protocols, data analysis, and write a final report		
Edoh Ognakossan Kukom	WorldVeg	Implement postharvest and processing training		
Alpha Sidy Traore	WorldVeg	Supervise field work and collect data in Mali		
Daniel Adu Boakye	WorldVeg	Supervise field work and collect data in Ghana		
Gundula Fischer	IITA	Design and implement gender studies on vegetable production		
Felix Badolo	ICRISAT	Perform comparative cost-benefit analysis over seasons		
Bola Awotide	WorldVeg	Perform comparative cost-benefit analysis over seasons		
Wubetu Legesse	WorldVeg	Advice and collect data on pests and diseases		
Bougouna Sogoba	AMEDD	Community mobilization technologies dissemination		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	Koutiala and Bougouni			
g. Start	April 2017			
h. End	March 2021			
1. Justification				
Participatory evaluation and diffusion of promising new vegetable cultivars will be carried out to deliver high value, multiple disease-resistant and nutrient-dense vegetable cultivars. Vegetable mono-cropping will be implemented with dissemination of farmers' preferred vegetable varieties and species. Twelve farmers (households) per village in each of the five action villages in each of the				

Bougouni and Koutiala districts (total of 60) will be selected to participate in testing and disseminating the four most popular vegetable crops (pepper, tomato, African eggplant, and cowpea). In each of the five target actions villages, improved/validated vegetable varieties and local varieties will be compared and disseminated across subsets of 10 households per village (validated or improved varieties vs. adapted local variety).
2. Objectives
2.1 Evaluate varieties of farmers' and market preferred vegetable species under rainfed and irrigated conditions through farmer participatory approaches and comparative cost-benefit analysis of seasons.
2.2 Promote information and knowledge exchange among farmers.
2.3 Train farmers on good agricultural practices in vegetable garden techniques, post-harvest and processing techniques.
2.4 Determine the profitability of vegetables over the two seasons of the year.
3. Research questions/hypotheses
3.1 Leaf and/or fruit yield of improved varieties of known and little-known vegetable varieties will increase significantly from yields of local varieties under irrigated and rainfed conditions.
4. Procedures
Sub-activity 1 *Conduct indigenous and exotic vegetable variety trials & demonstrations under rainfed conditions*. Leader: Jean-Baptiste Tignegre
(This sub-activity was not part of the workplan last year but needs to be implemented to achieve the output by enabling the year-round production of vegetables by women farmers in Koutiala and Bougouni). Ninety farmers in the communities of Bougouni and Koutiala will be implementing variety demonstrations at the technology parks and on farmers' fields to test/disseminate rainfed tomato, onion, African eggplant and vegetable cowpea to select high-yield and disease-resistant varieties. The field design will be randomized complete blocks with 4 replicates in the technology parks combined across 2 locations (Bougouni, Koutiala); non-lead farmers will test a single replicate of the above varieties. In each district, five villages will be selected to conduct demonstration trials. The twelve farmers will plant at least 3 improved varieties of each species including farmers' variety as the control variety. The villages of Dieba, Flola, Madina, Sibirila and Sirakele (Bougouni District), Zanzoni M'pessoba, N'Golonianasso, Nampossela (Koutiala district) will host the trials and demonstration fields. The technology parks will host the replicated trials. Two field days will be organized at transplanting and maturing stages to document production practices and farmers' preferences for improved varieties. Participatory testing and diffusion of promising new vegetable cultivars will be carried out to deliver high value, multiple disease-resistant cultivars in the rainy season. Data will be collected for leaf and fresh fruits yield, input & labor costs, varietal performances to plant diseases, farmers' perceptions and climatic data (annual rainfalls). Data will be collected on dry season trials and demonstrations to enable costs/benefits analysis of the season.
Sub-activity 2: Conduct sack garden vegetable variety trials and demonstrations to reduce malnutrition and generate income for women farmers in the dry season. Leader: Jean-Baptiste Tignegre
(This activity is new but it adds value to previous research results. The deployment of sack gardens aims at enabling vegetable production by women with no access to land or to a reliable water source for normal gardening. It involves recycled fertilizer bags as containers filled with soil and compost serving as plant substrate. It promotes space and water use efficiency and a diverse range of legume species grown in a confined space. Three to four cycles of production are possible annually. In the house, it appears as a source of food and ornamentals. The access is easy for all social categories in rural areas and urban and peri-urban farmers.

About 100 farmers in the two districts (Bougouni and Koutiala) will test tomato, onion, Amaranth, cabbage, and vegetable cowpea, using 50kg-content recycled fertilizer sacks in the dry season. Fifty farmers in each district will plant 25-30 vegetable seedlings in the side of these sacks, while amaranth and onion will be planted on the open top of the sacks (horizontal position).
The field design will be randomized complete blocks with 4 replicates in the technology parks combined across 2 locations (Bougouni, Koutiala); non-lead farmers will test a single replicate of Tomato, Amaranth, African eggplant, onion, cabbage, vegetable cowpea.
Data will be collected for leafy and fresh fruits, input & labor costs, varietal performances to plant diseases, farmers' perceptions (Tomato, Amaranth, African eggplant, onion, cabbage, vegetable cowpea, etc.). Comparative cost-benefit analysis for the different varieties, the prototype of sack gardens and seasons will be implemented.

Sub-activity 3: Improve the capacity of vegetable farmers on vegetable gardening and postharvest handling and processing techniques - Leader: Jean Baptiste Tignegre

1. *This activity was part of the workplan last year but needs to be implemented for continued empowerment of farmers to achieve the output.*

This activity will improve the capacity of vegetable farmers with training on vegetable gardens. The training sessions will focus on good agricultural practices for the implementation of nurseries, production itinerary, post-harvest handling and vegetable processing technologies.

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Days to 50 % flowering	WorldVeg
5.2 Number of plants bearing fruits per plot; fruit yield (kg/ha)	WorldVeg
5.3 Leaf yield	WorldVeg
5.4 Gender preferences for vegetable varieties	IITA
5.5 Comparative cost/benefit analysis of vegetables over the seasons	ICRISAT

6. Milestones

Deliverables	Means of verification	Date
6.1 A report on farmers training and trial establishment	Report included in the full report	Dec. 2018
6.2 Database on vegetables	Uploaded on Dataverse	May 2019
6.3 Field days organized	Project report with a list of participants disaggregated by sex	May 2019
6.4 Cost-benefit analysis implemented	Project reports	Dec. 2019
6.5 Chapter 7 in Africa RISING technology handbook on vegetable varieties - tomato (Rio Grande), African eggplant (L10), okra (Konni) for Ghana & Mali	WA technology handbook	Nov. 2018
6.6 Chapter 5 in Africa RISING technology handbook on sorghum-vegetable (tomato, pepper, eggplant, okra, roselle) intercropping	WA technology handbook	Nov. 2018

7. Sustainable intensification indicators

7.1 Productivity	Crop productivity at plot and farm level (Yield/ha)
7.2 Environmental	Plant biodiversity at field/plot level ((number of species & varieties)
7.3 Economic	Net income/ha at plot and farm level
7.4 Social	Gender equity at household level

7.5 Human	Capacity to experiment at community/landscape (% farmers experimenting)

8. How will scaling be achieved?
Scaling will be achieved through partnership with development partners (AMEDD, Women farmers' associations in Koutiala and Bougouni, NARES). Knowledge transfer and scaling strategies will include: establishment of research-for-development plots to demonstrate technologies; participatory and joint learning approaches for variety selection in the community-based technology parks as well as farm fields; development by WorldVeg of training of trainers and hands-on training for farmers.
9. How are the activities in this protocol linked to those of others?
Activities have links with those on vegetable and livestock production, and nutrition under protocol numbers: MA1121-18, MA1122-18 and MA2111-18.

10. Budget (US$)						
Outcome/Output/Activity	Sub-activity	Budget Line	ICRISAT	AMEDD	WorldVeg	IITA
Outcome 1/Output 1/Activity 1	MA1111-18	Personnel	14,950	1,500		
		Services	2,150	500		
		Supplies	2,000	1,500		
		Capital				
		Travel	5,000	1,000		
		Overhead (16%)	3,856	720		
		Total	27,956	5,220		
	MA1112-18	Personnel	6,500	1,500		
		Services	7,500	500		
		Supplies	5,500	1,500		
		Capital				
		Travel	10,500	1,000		
		Overhead (16%)	4,800	720		
		Total	34,800	5,220		
	MA1113-18	Personnel	10,000			
		Services	6,000			
		Supplies	3,965			
		Capital				
		Travel	5,000			
		Overhead (16%)	3,995			
		Total	28,960			
	MA1114-18	Personnel	3,000		8,000	
		Services	2,000		4,000	2,000
		Supplies	3,000		4,600	3,000
		Capital				
		Travel	5,000		5,000	3,000
		Overhead (16%)	2,080		3,416	

		Total	15,080		25,056	8,000
		Subtotal	106,796	10,440	25,056	8,000
	Grand Total	**150.252**				

Outcome 1:	Farmers and farming communities in the project area are practising more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.			
a. Output 1.1:	Research products for more productive, intensive, diverse, profitable and resilient crop (cereals, legumes, and vegetables); livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities.			
b. Activity 1.1.2:	Test and disseminate a combination of improved breeds, housing, feeding, health and breeding practices to intensify rearing of livestock (sheep, goat, pig, and poultry) for meat, egg and milk production.			
c. Sub-activity MA1121-18:	Efficient feed utilization through improved feed troughs.			
d. Research team				
Name	Institution	Role		
Augustine Ayantunde	ILRI	Coordination of sub-activity, training in the design of improved feed troughs and use, data analysis and final report		
Theophile Dembele	AMEDD	Coordination of training of farmers, data collection and report of the training		
Koita Seydou	AMEDD	Data collection and entry		
Oumar Samake	AMEDD	Supervise AMEDD activities		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	M'Pessoba, Sirakele, Zanzoni in Koutiala			
g. Start	October 2018			
h. End	March 2019			

1. Justification

Seasonal feed scarcity, particularly in the dry season is the norm in the Sudano-Sahelian zone of West Africa. The ad-hoc manner of feeding the available feed resources by the smallholder farmers is characterized by waste as animals eat part, and trample and urinate on the rest. Given the feed shortage particularly in the dry season, efficient utilization of the available feed resources is essential to minimize waste as to feed more animals. Under the Africa RISING project in Ethiopia, improved feed troughs have been designed, tested and evaluated for feeding ruminants (cattle, sheep and goats) by ILRI. Results from monitoring of the use of the improved feed troughs in four sites in Ethiopia showed that it saved 27% of the cereal and legume residues offered to the animals compared to the traditional feed troughs. Besides, the improved feed troughs led to a significant increase in the amount of manure collected. The success stories around this simple technology have led to an enquiry about the feasibility of testing the same technology in West Africa. This sub-activity is therefore aimed at testing, validating and demonstrating the effect of improved feed troughs on feed utilization by both cattle and small ruminants in the 3 Africa RISING intervention sites (M'Pessoba, Sirakele and Zanzoni) in Koutiala. Colleagues from ILRI Ethiopia will be engaged in this

sub-activity to train our AMEDD partner in the design and use of the feed troughs. The selected farmers will then be trained by AMEDD. Data will be collected on the amount of feed offered, the waste, cost and benefit, farmers' assessment of the usefulness of the improved feed troughs, the quantity of manure collected, and household labour expenditure on feeding the animals.		
2. Objectives		
2.1 The overall objective of this sub-activity is: (i) To test, validate and demonstrate the effect of improved feed troughs on feed utilization by both cattle and small ruminants in the 3 Africa RISING interventions in Koutiala. (ii) To increase the capacity of smallholder livestock keepers in improved feeding systems to reduce waste and improve animal productivity.		
3. Research questions		
3.1 What is the effect of improved feed troughs on feed utilization by cattle and small ruminants, particularly on the reduction of feed waste?		
3.2 What are the costs and benefits of the improved feed troughs?		
3.3 What is the effect of the improved feed troughs on the household labour allocation to animal feeding by gender? Does the improved feed troughs reduce time spent on feeding the animals by women?		
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc).		
Fifteen farmers will be selected randomly from M'Pessoba, Sirakele and Zanzoni in Koutiala out of which five will be women who will be trained in the use of improved feed troughs for cattle and small ruminants. Each farmer will be provided with one improved feed through which will be compared with the traditional feed troughs. The designs of the improved feed troughs will be presented to farmers for feedback. The amount of crop residue offered (both in the morning and afternoon) and that wasted during the feeding process will be measured for six consecutive days, both for the traditional practice (spreading a portion of the feed on the ground) and wooden troughs. The amount of time spent in looking after the animals while feeding (bringing back dispersed feed, keeping animals to feed comfortably) will be recorded for both practices. A survey questionnaire will be administered to all participating farmers to document their opinions about the contribution of the technology to feed management and its acceptance. A simple cost-benefit analysis will be done, considering the cost of construction of the feed troughs, the price of crop residues in the local market, and the total amount of the crop residue available for livestock feeding (to be derived from crop data). Samples of the feed offered and the left-overs will be analysed for both improved feed troughs and traditional feeding practice. Stovers of dual-purpose sorghum from the agronomic trial will be used for testing of the improved feed troughs in M'Pessoba		
5. Data to be collected and uploaded	Responsibility/Institute	
5.1 Quantity of feed offered and leftovers, the chemical composition of feed offered and left-overs, cost and benefit of the improved feed troughs, and time spent feeding the animals by different gender group.	AMEDD	
6. Milestones		
Deliverables	Means of verification	Date
6.1 Report on testing and evaluation of the improved feed troughs compared to traditional practice	Report uploaded on	Mar. 2019

	Africa RISING repository	
6.2 Training report on improved feed troughs	Report uploaded on Africa RISING repository	Dec. 2018

7. Sustainable intensification indicators	
7.1 Productivity	Input use efficiency (quantity of feed saved from waste)
7.2 Environmental	
7.3 Economic	Profitability (cost and benefit of improved feed troughs)
7.4 Social	Gender equity (time spent in feeding the animals by gender)
7.5 Human	

8. How will scaling be achieved?
The involvement of AMEDD in the testing and validation of the improved feed troughs will facilitate scaling of the technology as AMEDD is a developmental NGO. Besides, the USAID Mali Livestock Technology Scaling Program will provide a platform for scaling of the improved feed troughs after testing and validation.
9. How are the activities in this protocol linked to those of others?
Linked to the protocol on Feed health intervention as improved feed troughs will lead to better utilization of feed by the animals and improved productivity. This sub-activity is also linked to the sub-activity on dual-purpose sorghum as the residue from the agronomic trial in M'Pessoba will be used to feed the animals through the improved feed troughs.

10. Budget (US$)			
Outcome/Output/Activity	Sub-activity	Budget Line	ILRI
Outcome 1/Output 1/Activity 2	MA1121-18	Personnel	29,385
		Services	22,892
		Supplies	4,500
		Capital	0
		Travel	8,440
		ILRI Overhead (15%)	9,783
		Subtotal	75,000
		ICRISAT OH (16%)	12,000
		Total budget	**87,000**

Outcome 1:	Farmers and farming communities in the project area are practising more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.
a. Output 1.1:	Research products for more productive, intensive, diverse, profitable and resilient crop (cereals, legumes, and vegetables); livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities.
b. Activity 1.1.2:	Test and disseminate a combination of improved breeds, housing, feeding, health and breeding practices to intensify rearing of livestock (sheep, goat, pig, and poultry) for meat, egg and milk production.
c. Sub-activity MA1122-18:	Feed health interventions for improved small ruminant production.

d. Research team

Name	Institution	Role
Augustine Ayantunde	ILRI	Coordination of sub-activity, design of survey instruments, data analysis and final report
Theophile Dembele	AMEDD	Coordination of data collection and entry, report of the survey administration, and geographic coordinates of the participating households
Koita Seydou	AMEDD	Data collection and entry
Oumar Samake	AMEDD	Supervision of AMEDD activities
Gundula Fischer	IITA	Design of survey instruments and data analysis

e. Student(s)

Name	Institute	Degree	Start	End

f. Location(s)	Sirakele, Zanzoni in Koutiala
g. Start	August 2018
h. End	March 2019

1. Justification

Under the feed-health intervention study for improved small ruminant production in Koutiala (Sirakele and Zanzoni), we have collected data on animal performance (average daily gain, flock dynamic), manure production, and cost and benefit which covers the productivity, environmental and economic domains of the sustainable intensification assessment framework. We do not have the necessary data for the human and social domains regarding this feed-health intervention. The objective of this sub-activity is to collect additional data on human and social domains so that we can assess the feed-health intervention based on the 5 domains of the sustainable intensification assessment framework. This sub-activity will entail developing short survey instruments to collect data on how the feed-health intervention impacts on household food security, nutrition, and gender in terms of decision making and benefit sharing from the improved small ruminant production. The same twenty households in the 2 communities involved in the feed-health intervention will be involved in the study. In addition to the data to be collected on feed-health intervention, a manuscript will be drafted and submitted to a journal for publication based on the study.

2. Objectives		
2.1 The objective of this sub-activity is: (i) To collect additional data on social and human domains to assess the feed-health intervention based on the 5 domains of the sustainable intensification assessment framework.		
3. Research questions		
3.1 What is the effect of feed-health interventions on gender and household food security and nutrition?		
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc).		
A survey will be conducted on the perceived effect of feed and health interventions on gender equity and household nutrition, specifically the use of income from the sale of small ruminants on household food consumption and dietary diversity. Given that the flock monitoring was completed, the only feasible way to collect additional data on the effect of the intervention on gender and nutrition is to interview the households involved in the study. The twenty farmers involved in the feed and health intervention in each community will be surveyed on their perception of the intervention on gender and household food and nutrition security. With the additional data on social and human domains, the sustainable intensification assessment framework will be used to assess the feed and health intervention. In addition, the data collected will be used for the chapter of the handbook on livestock technologies.		
5. Data to be collected and uploaded		Responsibility/Institute
5.1 Household labour allocation by gender for managing small ruminants, decision making and sharing of benefits from the sale of small ruminants, the contribution of income from the sale of small ruminants to household food consumption and dietary diversity and coordinates of the participating households.		ILRI and AMEDD
6. Milestones		
Deliverables	Means of verification	Date
6.1 Data on the perceived effect of the feed-health intervention on household nutrition and gender equity	Report uploaded on Africa RISING repository	Mar. 2019
6.2 Report of the survey on the effect of feed and health intervention on gender equity and household food and nutrition security	Report uploaded on Africa RISING repository	Dec. 2018
6.3 Chapter in technology handbook on livestock technologies	WA technology handbook	Oct. 2018
6.4 Draft manuscript on feed health intervention	Draft manuscript shared with the chief scientist for review	Mar. 2019
7 Sustainable intensification indicators		
7.1 Productivity		
7.2 Environmental		
7.3 Economic	Profitability (amount proceeding from the sale of small ruminants spent on household food)	
7.4 Social	Gender equity (time spent on small ruminant management by gender)	

7.5 Human	Nutrition (household dietary diversity score)

8. How will scaling be achieved?	
The feed-health intervention is being scaled up by USAID Mali Livestock Technology Scaling Program in Mopti and Sikasso regions of Mali.	
9. How are the activities in this protocol linked to those of others?	
Linked to the protocol on improved feed troughs (MA1121-18) as some of the data collection instruments developed for flock monitoring under Feed-health intervention will be adapted for data collection on feed utilization with improved feed troughs. Besides, some households who have participated in the feed-health intervention will be selected for the testing of the improved feed troughs.	

10. Budget			
Outcome/Output/Activity	Sub-activity	Budget Line	ILRI
Outcome 1/Output 1/Activity 2	MA1122-18	Personnel	7,251
		Services	7,314
		Supplies	5,771
		Capital	0
		Travel	7,490
		Overhead (15%)	4,174
		Subtotal	32,000
		ICRISAT OH (16%)	5,120
		Total	**37,120**

Outcome 1:	Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.			
a. Output 1.1:	Research products for more productive, intensive, diverse, profitable and resilient crop (cereals, legumes, and vegetables); livestock (sheep, goats, cattle, poultry and pigs) and integrated crop-livestock farming systems are identified and disseminated to farmers through development partners in the intervention communities.			
b. Activity 3:	Test and disseminate integrated crop-livestock-soil systems to increase and sustain productivity and reduce risk.			
c. Sub-activity MA1131-18:	From a qualitative multi-criteria assessment to a detailed economic and risk analysis of crop-livestock technology options at farm level.			
d. Research team:				
Name	Institution	Role		
Katrien Descheemaeker	Wageningen University	Activity leader – student supervisor		
Jeroen Groot	Wageningen University	Activity co-leader		
Ken Giller	Wageningen University	Student supervisor		
Bouba Traoré	ICRISAT	Collaborator		
e. Student(s)				
Name	Institute	Degree	Start	End
Arouna Dissa	Wageningen University	PhD	Jan 2017	Dec 2020
Eva Huet	Wageningen University	PhD	Jan 2017	Dec 2020
Jacob Hambuechen	Wageningen University	MSc	Sep 2018	May 2019
f. Location(s)	Koutiala			
g. Start	June 2018			
h. End	May 2019			
Justification				
Different crop-livestock intensification options and technologies have been tested in the Africa RISING project and other related research for development projects in the region. A notable example of such options includes soil fertility management technologies (such as mineral fertilizer, organic manure, including leguminous crops), fodder production, treatment and storage options, manure and compost management, stall feeding of cattle, small ruminant fattening. Adoption of these options by farmers depends not only on their performance in terms of improving productivity but also on their effects on indicators in a range of sustainable intensification domains. This activity seeks to add to a previous qualitative multi-criteria analysis by quantifying economic indicators and risk. This is important because adoption decisions by farmers depend not only on yield but to a large extent also on profit and risk of investment. Understanding farmers' perception of these criteria and of the risk involved is key in assessing farmer decision making and will help the research and development community to design interventions that are tailored to the farmers' needs and context. The detailed quantitative analysis of economic indicators will investigate enterprise budgets for livestock (e.g. milk) and for crops (e.g. maize) linked to the value chains that were mapped last year (outcome 3), total agricultural profits per households, probability that profits are less than thresholds related to poverty and living income, income diversification index, market participation and market orientation. Additionally, risk experienced by farmers and risk management strategies will be assessed, with the aim to understand how crop-livestock intensification options can help to cushion farmers against various types of risks.				
2. Objectives				
2.1 To assess the feasibility of a range of economic indicators, including enterprise budgets for livestock and crops, total agricultural profits per household, income diversification index, market participation and market orientation to evaluate progress towards sustainable intensification				

2.2 To quantify effects of crop-livestock intensification options (e.g. integrated soil fertility management, fodder and manure management, stall feeding) on economic indicators.
2.3 To understand farmers' risk perceptions and common risk management strategies, including the role of crop-livestock intensification options in risk cushioning.
3. Research questions
3.1. How useful are the above-mentioned economic indicators to evaluate the effect of crop-livestock intensification options?
3.2 What is the effect of crop-livestock intensification options on selected economic indicators and risk?
3.3 How do farmers perceive and manage risk?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
Project reports, data and publications from the Africa RISING project and other related projects in the region (such as the "Pathways to Agro-ecological intensification" project in Koutiala, funded by the McKnight Foundation and led by WUR) will be compiled. Specifically, information with regards to effects on crop yield and animal productivity will be combined with a description of the input levels (labour, nutrients, fodder) required for the options. Together, these will allow the calculation of the economic indicators. Household surveys will be conducted within the "Pathways to Agro-ecological intensification" to collect (i) information on the management of the different farm enterprises, income sources and market participation (ii) data on risk perception, its severity, frequency and farmer coping strategies. Households will be selected with stratified random sampling to ensure a representative proportion of different farm types. Within the households, different household members, including young and female household members, will be interviewed on risk perception to understand gender diversity.

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Economic data: input application rates and costs, labour input, product prices, income sources, market participation, enterprise budgets	WUR
5.2 Risk data: severity and frequency of different risk types; risk management; risk perception	WUR

6. Milestones		
Deliverables	Means of verification	Date
6.1 Economic indicators identified that are feasible to evaluate sustainable intensification	Report	Jan. 2019
6.2 Effects of crop-livestock intensification options on economic indicators quantified	MSc thesis report	May 2019
6.3 Severity and frequency quantified of risks perceived by farmers to be important	Draft paper Submitted paper	Jan. 2019 May 2019
6.4 Contribution to technology handbook chapters 1, 2 and 8	Technology handbook	Nov. 2018

7. Sustainable intensification indicators	
7.1 Productivity	Crop yield, animal productivity
7.2 Environmental	
7.3 Economic	Risk, enterprise budgets for livestock and for crops, agricultural profit, living income, probability that profits are less than thresholds related to poverty and living income, income diversification index, market participation and market orientation
7.4 Social	N.A.
7.5 Human	Adaptive capacity

8. How will scaling be achieved?
Quantified effects of crop-livestock intensification options on economic indicators and risk will allow a better understanding of important constraints and bottlenecks to adoption by farmers. This can be considered by decision-makers in tailoring interventions for more widespread uptake. A disaggregated analysis, enabled by information gathered from different types of farmers and gender groups through the household surveys, will inform a more effective tailoring of options.
9. How are the activities in this protocol linked to those of others?

10. Budget (US$)			
Outcome/Output/Activity	Sub-activity	Budget Line	WUR
Outcome 1/Output 1/Activity 3	MA1131-18	Personnel	12,000
		Services	
		Supplies	
		Capital	
		Travel	5,250
		ICRISAT Overhead (16%)	2,760
		Total	**20,010**

Outcome 1:	Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.			
a. Output 1.2:	Integrated management technologies and practices to improve and sustain productivity and ecosystems services of the soil, land, water and vegetation resources are developed and disseminated to farmers and development partners in the intervention communities.			
b. Activity 1.2.1:	Test and disseminate land, soil and integrated land-soil technologies and practices to improve and sustain productivity and ecosystems services at the farm and landscape/watershed levels.			
c. Sub-activity MA1211-18:	Investigating the impact of contour bunding technology on environmental, social, livelihood and economic benefits in two agro-ecologies of southern Mali.			
d. Research team				
Name	Institution	Role		
Birhanu Zemadim	ICRISAT	Leader, Land and Water Management		
Felix Badolo	ICRISAT	Socio-economic analysis		
Jummai Yila	ICRISAT	Gender analysis		
Mahamadou Dicko	AMEDD	Community mobilization		
Karamoko Sanogo	ICRISAT	Research assistant		
e. Student(s)				
Name	Institute	Degree	Start	End
Intern	IPR/IFRA Katibougu	BSc	Aug. 2018	Feb. 2019

f. Location(s)	Koutiala and Bougouni
g. Start	April 2017
h. End	March 2019
2. Justification	

Land and water management practices like that of contour bunding, drip irrigation and shallow wells have been implemented by farmers over time in southern Mali. Farmers use these practices to improve yield performance and increase the household income (Gigou, J., et al., 2006[24]; Birhanu, Z.B. and Tabo, R., 2016 [25]). Literature shows that the implementation of contour bunding can improve cotton yield by 30% and reduce erosion rate by 40% at farmers' field level (Traoré, K.B., et al., 2004[26], Birhanu, Z., 2015[27]). This work was mainly done through the cotton expansion program by the state-owned company in the past ten to fifteen years. From the years 2014 to 2017 the impact of contour bunding technology (CBT) on crop productivity has been followed by collecting and analyzing data. With CBT application the grain yield of sorghum was doubled. For cowpea, the grain yield increment was 81%. Evidence of yield improvement for maize and groundnut was also observed. The overall advantage of CBT would be complete with more data on environmental (for example soil moisture), social, livelihood and economic domains of the sustainable agricultural intensification options. In this regard data on soil moisture that have been collected over the past years will be analyzed and reported. New sets of data on the social, livelihood and economic benefits of CBT will help to make firm conclusions and recommendations regarding CBT applications in different agro-ecological environments of southern Mali.

2. Objectives

2.1 Evaluate the impact of contour bunding technology (CBT) using the agricultural sustainable intensification domains in two agro-ecologies of southern Mali.

3. Research questions

3.1 What variations exist over time on environmental gains (e.g. soil water enhancement) as a result of CBT practices, and by what rate was soil moisture enhanced with the introduced CBT practices to help bridge dry spells, mitigate terminal drought and improve crops maturity?

3.2 What were the improvements made on the available food crops as a result of CBT practices on farm level. It refers to the diversity of food available to the household level since CBT implementation. The base is farmers knowledge which will be done through a socio-economic survey.

3.3 What are the improvements on the diversity of crops grown and how much of the produced crops were available for sale and household consumption.

3.4 What are the variability and distribution of productivity, income and assets at each agro-ecologies as a result of long-term CBT application

4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)

[24] Gigou, J, Traoré, K., Giraudy, F., Coulibaly, H., Sogoba, B., & Doumbia, M. (2006). Aménagement paysan des terres et réduction du ruissellement dans les savanes africaines. *Cahiers Agricultures*, 15, 116-122.

[25] Birhanu, ZB. & Tabo, R. (2016). Shallow wells, the untapped resource with a potential to improve agriculture and food security in southern Mali. *Agric. & Food Secur*, 5:5.

[26] Traoré, KB. Gigou, JS. Coulibaly, H., & Doumbia, MD. (2004). Contoured ridge tillage increases cereal yields and carbon Sequestration. In: 13th International Soil Conservation Organisation Conference, Brisbane July 2004, Conserving Soil and Water for Society: Sharing Solutions, 126, 10pp.

27 Birhanu Zemadim 2015, Contours of a success story, Expanding Contour Bunding Technology for Improved Livelihood Benefits in Mali, Inclusive Market Oriented Development. Demand Driven Innovation Benefitting the Poor. ICRISAT IMOD Exemplars, Vol (2) pp 75-82. http://www.icrisat.org/PDF/IMOD-Exemplars-Volume-II.pdf

The work involves desktop studies of soil moisture data collected in phase I of Africa RISING project (soil moisture data is available from 2014 to 2017). New sets of sex dis-aggregated survey data on the social, livelihood and economic benefits will be collected analyzed and reported. Agro-ecological characterizations will be conducted based on the available biophysical information. A watershed approach will be used to characterize the different agro-ecological environments based on the SI domains using information on population density, number of households, soil type, climate pattern, market access, number and type of past natural resources management practices, slope and land use pattern.

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Survey data on social, livelihood and economic benefits	ICRISAT/AMEDD
5.2 Cleaned data on soil moisture	ICRISAT

6. Milestones		
Deliverables	Means of verification	Date
6.1 Data on soil moisture, survey data on social, human and economic	Metadata and cleaned data uploaded on Dataverse	Jan. 2019
6.2 Report on long-term CBT impact on social, environmental, livelihood and economy	Report included in the full report to IITA and uploaded on Africa RISING West Africa Wiki page	May 2019
6.3 Technology handbook chapter: Technology 2: Land and water management strategies; Mali. Chapter 4: Strategies for improving land, soil and water management	WA technology handbook	Dec. 2018

7. Sustainable intensification indicators	
7.1 Environmental	Farm level: Soil moisture (percentage of volumetric moisture content)
7.2 Economic	Field/Plot level: Net income ($/crop/ha/season), coefficient of variability of net income.
7.3 Social	At household level: Decision-making about production, marketing (by crop), At administrative level: Variability and distributions of productivity (Yield gain, and variability of yield gain), income and assets.
7.4 Human	At field/plot level: Diversity of crops grown (% of all land) disaggregated by consumption versus sale.

8. How will scaling be achieved?
Scaling is achieved through field demonstration of technologies perceived important by farmers. During phase I of the project we have already established that contour bunding associated with agroforestry options are suited for scaling. Local NGOs, AMEDD and FENABE, have received appropriate training to scale the technology to a number of farmers.
9. How are the activities in this protocol linked to those of others?
This activity has been linked to most agronomic and soil fertility improvement subactivities proposed in the current study. The productivity component and part of the Environmental Sustainability Indicators (SI) have been conducted over the past three years (2015-2017). To

complete the five SI domains the study would be evaluating the impact of contour bunding technology on environmental (soil moisture), economic, social and human.

Outcome 1:	Farmers and farming communities in the project area are practicing more productive, resilient, and profitable and sustainably intensified crop-livestock systems linked to markets.				
a. Output 1.2:	Integrated management technologies and practices to improve and sustain productivity and ecosystems services of the soil, land, water and vegetation resources are developed and disseminated with farmers and development partners in the intervention communities.				
b. Activity 1.2.1:	Test and disseminate land, soil and integrated land-soil technologies and practices to improve and sustain productivity and ecosystems services at the farm and landscape/watershed levels.				
c. Sub-activity MA1212-18:	Improving crop-livestock productivity and household income through the use of contour bunding and agroforestry options.				
d. Research team					
Name	Institution	Role			
Kalifa Traore	IER	Activity leader			
Oumar Samake	IER	Field implementation			
e. Student(s)					
Name	Institute		Degree	Start	End
Cheick Oumar Dembele	IER		PhD	2017	2020
Fotigui Tamboura Cisse	IER		MSc	2018	2019
f. Location(s)	Bougouni and Koutiala				
g. Start	March 2017				
h. End	April 2019				

1. Justification

Key elements to ensure sustainability of agriculture-livestock systems are the adequate production of quality forage for animal supplementation but also the availability of water and soil nutrients (Penning de Vries and Djiteye, 1982). Among these quality forages, fast-growing nitrogen-fixing tree species and herbaceous plants occupy a prominent place. According to Breman and Kessler (1995), the power to concentrate and save nutrients, produce and maintain high biomass quantity exceeds far that of cereals and other grass species. All the fast-growing nitrogen-fixing trees (FGNFT) are not acceptable to livestock because of nitrogen content and availability.

A study on fodder yield and nutritive value of many trees species in West African humid areas (Larbi et al., 2005), showed that *Gliricidia sepium and Leucaena leucocephala,* were identified to have high potential for the development of integrated crop-livestock agroforestry technologies because of fodder yield, concentrations of CP, NDF, ADF and lignin. Larbi et al. (2005) reported that coppicing regrowth of these species could be harvested between 16 and 20 weeks to maximize yield and quality of the fodder. In Western Kenya, a biomass yield of 21 tons ha^{-1} was observed with *Sesbania sesban* on many nutrient-depleted soils (Sjogren et al., 2010). It is in this context that we propose to study possibilities of introducing fast-growing forage tree species in farmer's fields under Contour Bunding (CB) techniques.

Traore et al (2017b) reported that water storage was always higher in CB plots compared to control plots with a surplus of 0.23 mm day^{-1} in 2012 and 0.43 mm day^{-1} in 2013 in the CB plots over the monitoring period in the Cinzana Sahelian area of Mali. Also, millet grain yield in 2012,

2013, and 2014 was statistically higher in CB plots compared to the control with yield difference ranging from 301 kg ha^{-1} in 2012 to 622 kg ha^{-1} in 2013. These values corresponded to an increase of 60 and 56%, respectively. Concerning sorghum grain yield, it increased consistently from 461 kg ha^{-1} in 2012 to 1378 kg ha^{-1} in 2014. Moreover, the qualitative assessment done by farmers on the effects of CB revealed that rainwater was kept between contour ridges reducing runoff and consequently increasing infiltration and producing higher crop yields (grain and straw) in contoured plots than in the control plots. Also, with the use of CB, soil moisture was found to be better conserved and allowed field operations for an extended 7 to 10 days (Traore et al., 2017a).
2. Objectives
2.1 Monitor growth and quantify forage production of fast-growing trees species *(Gliricidia sepium and Leucaena leucocephala)*
2.2 Increase crop yield through improving rainwater conservation in improved cropping systems
2.3 Study the effects of fast-growing trees species on soil physicochemical properties
3. Research questions
3.1 How can the use of Contour Bunding Technology (CBT) increase crop grain and straw biomass yield?
3.2 Does the use of CBT increase trees growth and biomass?
3.3 Does the use of CBT improves soil physical and chemical properties?
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)
Twenty collaborative farmers will be chosen in two villages because this number is what is feasible with accurate data according to the experiment type. Prior to the implementation, soil sampling will be performed using an auger at 0-20 cm and 20-40 cm depth and samples will be sent for physicochemical analysis in the Soil-Water - Plant Laboratory of IER. The field of each farmer will be divided into two parts. The first part is under contour bunding (CB), i.e. ridges follow contour lines, and the second one with farmer's practices labeled as non-contour bunding (NCB) implemented as a control. The contour lines will be planted with fast-growing trees species chosen by farmers, such as *Gliricidia sepium* and *Leucaena leucocephala*. Tree species will be planted on the crest of the contour bund which will be 0.8 m width and 100 m length. The distance between tree species will be 3 m. Trees will not be planted in the 10 x 4 m plot but along the contour bund. Therefore, 17 trees will fit into a 40 m^2 area along the contour bund. In each part, 10 trials based on cotton or sorghum intercropped with soybean will be implemented regarding the activities of the PhD thesis. In each trial only the inputs (fertilizer, pesticides) will be supplied by researchers, all the other factors (crop species, varieties, tillage technique, maintenance, etc.) will be those of farmers. In two fields, soil moisture will be monitored using TDR probes in CB and NCB plots.
Data will be analyzed using STATBOX 7. Analyze of variance will be used to assess the performance of treatments and means comparison by LSD procedure.

5. Data to be collected and uploaded	Responsibility/Institute
5.1 Biophysical data: height, basal diameter, crown radius and diameter at 1.3 m height when possible) will be performed on fast-growing trees species starting at their plantation date.	IER
5.2 Cultural operations: Plowing or ridging date, planting date, emergence date, thinning date, planting density, plant density at harvest, plant height, grain yield, straw yield, thousand grain yield.	IER
5.3 Soil physical and chemical properties	IER
5.4 Soil moisture content	IER
5.5 Trees biophysical parameters	IER

5.6 Crop yield (straw and grain)		IER
6. Milestones		
Deliverables	Means of verification	Date
6.1 Report	Interim report submitted to ICRISAT	Dec. 2018
6.2 Data on agronomic and tree growth	Data uploaded on Dataverse	Dec. 2018
6.3 Recommendation of best agro-forestry technology in combination with CBT	Report and brief to be uploaded on Africa RISING West Africa Wiki page	Mar. 2019
6.4 Farmer exchange visit	Field visit, technical report and IER's yearly Committee of Program report to be uploaded on Africa RISING West Africa Wiki page, pictures (photo and film)	May 2019 (Africa RISING technical report), Jun. 2019 (IER's yearly Committee of Program report)
7. Sustainable intensification indicators		
7.1 Productivity	Crop production (yield), input use efficiency, cropping intensity at farm level	
7.2 Environmental	Soil quality (nutrients level) at plot level	
7.3 Economic	Profitability, returns to land, labor and inputs, diversification of income at household level	
7.4 Social	Gender equity, social cohesion at household level	
7.5 Human		

8. How will scaling be achieved?
In September, when there is very little field work, a farmer exchange visit will be organized to show the growth and development of the different fast-growing trees species planted on the crest of the contour line. They will be trained in how and when to start the nursery and trees plantation. In each village, at least 40 farmers will be part of the exchange visits. Farmers who have developed interest in the technology will be recorded and new materials (brief notes) will be made available for them.
9. How are the activities in this protocol linked to those of others?
This activity is linked to improving crop-livestock interaction to help agricultural activities and also small ruminant fattening.

10. Budget (US$)				
Outcome/Output/Activity	Sub-activity	Budget Line	ICRISAT	IER
Outcome1/ output2/ activity1	MA1211-18	Personnel	45,000	
		Services	7,000	
		Supplies	16,500	
		Capital		
		Travel	7,500	
		Overhead (16%)	12,160	
		Total	88,160	
	MA1212-18	Personnel		3,000

		Services		2,000
		Supplies		3,559
		Capital		
		Travel		5,000
		Overhead (16%)		2,169
		Subtotal	88,160	15,728
		Grand Total	**103,888**	

Outcome 2:	More farmers and farm families in the intervention communities are adopting technologies and practices to improve nutrition, food and feed safety, post-harvest handling and value addition.			
a. Output 2.1:	Improved technologies, practices and habits to increase and diversify the production and consumption of more nutritious food by farm families, especially by women and children are developed.			
b. Activity 2.1.1:	Evaluate a nutrition strategy to harmonize the nutrition activities with the national nutrition approaches and link them to the crop and livestock activities.			
c. Sub-activity: MA 2111-18	Evaluation of nutrition-sensitive-agriculture options in Mali.			
d. Research team				
Name	Institution	Role		
Jean-Baptiste Tignegre	Worldveg	Sub-activity leader: Public health/nutritionist		
Honafing Diarra	Worldveg	Nutritionist/field implementation		
Awa Konaté	Worldveg	Field technician		
Pierre Coulibaly	AMEDD	Field technician		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	Project communities in Mali			
g. Start	June 2018			
h. End	June 2019			
1. Justification				
Despite being the food basket of Mali, the prevalence of malnutrition remains high in the Sikasso Region. Around one-third of children are stunted or chronically malnourished and infant and young child feeding practices are very poor including early weaning of children, poor complementary feeding, poor dietary diversity and poor hygiene practices. More effort to leverage agriculture to improve the nutrition of smallholder farmers and especially young children are needed for the achievement of the sustainable development goal and eradication of malnutrition and poverty. Well-tailored agriculture intervention coupled with nutrition and health behavior change communication can potentially help to address several immediate and intermediary causes of malnutrition including dietary diversity, complementary feeding practices, the incidence of infection and diseases and care practices. It can potentially improve the nutrition of the mother and the baby during the first 1000 days of the child's life. Agricultural practices and interventions should be better adapted and redesigned to maximize health and nutrition benefits and to reduce malnutrition and diseases. In Mali, inadequate intakes of nutrient-rich foods are widespread primarily because staple diets and				

complementary feedings are predominantly cereal based and intakes of nutritious foods including fruits, vegetables and animal source foods are low.

Data collected in communities targeted by Africa Rising activities have shown that behaviour change communication and vegetable training activities have succeeded to increase the consumption of vegetables and fruits among target beneficiaries, without affecting the children dietary diversity score; 50% of children aged 6-23 months are consuming less than four food groups per day. However, disaggregation by age shows that children aged 6-8 months at the beginning of the weaning period are eating only two food groups per day compared to children aged 9-11 months and 12-23 months that were eating three and four food groups respectively. Therefore, there is a need to revise the project approach with the aim of improving not only some food groups but to make sure that from the beginning of the weaning period and as soon as the child reaches 6 months, the mother starts giving a balanced and diversified diet.
The nutrition activities proposed in this study have been designed to target women and children and especially women with children aged 4-8 months. Women play a critical role in household nutrition as the primary producers of micronutrient-rich vegetables, and they are responsible for the purchase of food at the local markets and preparation of food in the home. In addition, they take care of the children and especially during the weaning period. Consequently, the integrated package for improving household nutrition through this intervention will continue to be given to women in the selected Africa RISING intervention communities. Women will also be supported to establish mobile gardens and use the product of this mobile garden to enrich the complementary foods of young children. In addition, community mobilization activities will also target men and grandmothers in order to create an enabling environment where behavior change will be feasible and sustainable.

2. Objectives

2.1 Improve women's nutrition knowledge through nutrition field schools

2.2 Evaluate options for improving the dietary diversity of households

3. Research questions

3.1: Can women support in vegetable production and behaviour change communication on improved infant and child feeding practices lead to improved child dietary diversity?

3.2 Do self-efficacy, family support, community support and household welfare potentiate behavior change with regard to child feeding practices?

3.3: Can women training in agriculture lead to increased product diversity and dietary diversity without compromising child care practices?

3.4: Can use of sack gardens be an alternative to poor land accessibility to women?

4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)

4.1: Training for improving nutritional knowledge of community and extension workers:

This sub-activity was implemented in 2017 under MA2211-17 sub-activity but needs to be revised and still be implemented up to February 2019 to help to consolidate beneficiary's knowledge).
Community volunteers, agriculture and health and nutrition workers in the intervention communities will be trained in 'Behavior Change Communication' (BCC) in nutrition and health. This will equip community workers with the technical, action-oriented knowledge and counselling skills needed to support pregnant women, breastfeeding mothers with children less than two years of age and other key family members to adopt nutrition practices. Refresher training to recall and reinforce previously acquired knowledge and skills will be organized every six months.

4.2: Evaluate quantitative and qualitative nutritional options in the intervention zones - strategies for improving household nutritional diversity:

Mobile-gardens aim at enabling women without land ownership and limited access to water to produce vegetables for household consumption. In Koutiala District, two hundred households with women of childbearing age and nursing mothers with children aged 4-8 months randomly selected from intervention communities and control will receive support in vegetable production with the establishment of sack gardens and behavior change communication in nutrition and WASH. The impact of providing community nutrition trainings on improved nutrition practices for young children will be assessed. The sack gardens will help to improve the accessibility of nutrient-rich vegetables for complementary feeding. At least 100 households will all be assigned to the following treatments: Combination of communication for social and behavior change in nutrition, WASH and agriculture in addition to agriculture support and trainings for intervention groups,

1. Behaviour change communication training in nutrition and agriculture support in vegetable growing
2. Agriculture support in vegetables. Extension workers will conduct monthly behavior change communication sessions in target communities on improved nutrition practices and home visits to counsel and support mothers and their families. This aims to equip the women of childbearing age and especially lactating mothers with children below aged 6-24 months and pregnant women with knowledge and skills to foster adoption of proper health care and nutritional practices.

Women with children aged 4-8 months will be identified and organized to join existing women support groups in target villages which gather twice each month at the village level to discuss their experiences and learn optimal child care practices, feeding, health, and sanitation, gardening and small livestock rising. Some of the old members of community support groups, mainly the ones with good facilitation skills able to facilitate project activities will remain as community support group members since they already have a good level on nutrition knowledge, they can facilitate the organization of project activities at the village level and organize community mobilization activities. Newly recruited mothers of infants aged 6-8 months will be encouraged to join these old members to facilitate their continuous learning process at the community level.. Nutrition Club meetings will be facilitated by a trained community worker. Separate sensitization meetings with community leaders, fathers and grandmothers will be conducted every two months to foster community mobilization and create and strengthen an enabling and supportive environment for behavior change. Data on young child nutrition practices including initiation of complementary feeding, breastfeeding practices, dietary diversity scores, the frequency of feeding, type of foods/fluids, hygiene practices and responsive feeding practices will be collected at the baseline and after four months to monitor behavior change and adoption of good practices. A cluster non-randomized controlled trial will be used to collect quantitative and qualitative data on dietary diversity score, knowledge, attitude and practices primary data from mother/child pairs. This means a controlled pre-test/post-test design involving two cross-sectional surveys at baseline and endpoint follow-up will be used to determine the outcome/impact of the program. This will involve making observations before and after the implementation of the intervention which will give an indication of the changes that have taken place with time. Additionally, a comparison between intervention and control communities will show the changes which can be attributed to the program interventions.

5. Data to be collected and uploaded in Dataverse	Responsibility/Institute
5.1. Monitoring data household nutrition (consumption of different food types)	WorldVeg
5.2 Vegetable garden production data	WorldVeg

6. Milestones		
Deliverables	Means of verification	Date

6.1 Home garden (at least 100 mobile nutrition gardens in Sirakélé and Mpessoba) established and monitored	Reports/brief on home gardening to be uploaded on Africa RISING West Africa Wiki page	Mar. 2019
6.2 Training in best nutrition practices and awareness	Reports submitted to Africa RISING and uploaded on Wiki page	Jan. 2019
6.3. At least one article published	BMC nutrition journal	Jun. 2019
6.4 Chapter 7: Improving household nutrition and food quality on ''Approaches for improving household nutrition; Ghana & Mali'' for technology handbook	WA technology handbook	Dec. 2018

7. Sustainable intensification indicators	
7.1 Social	Gender equity, social cohesion at household level
7.2 Human	Nutrition (household, women and children dietary diversity scores, percentage of children consuming a minimum acceptable diet, prevalence of stunting and wasting)

8. How will scaling be achieved?
The training approach is the cascade training or training of trainers. This approach will enable to strengthen the capacity of lead beneficiaries, who will then train other beneficiaries once back in their village. This will enable scaling up of best practices to more people in target villages. The technique of mobile garden will also be scaled at the community level for the first time in Mali.
9. How are the activities in this protocol linked to those of others?
Communication for social and behavior change will focus on dietary diversification and production and consumption of a large variety of crops including cereals, legumes, tubers, fruits and also animal foods including poultry, eggs, small ruminants. In addition, behavior change communication on nutrition and WASH will be organized for identified beneficiaries. This approach will help to strengthen the link between the different activities implemented by Africa RISING project. Beneficiaries will be introduced not only to improve vegetable seeds but also improved cereals, fruits, and legumes seeds or materials. Advocacy activities will also be organized to make sure that they start a small livestock husbandry with the aim of improving the accessibility of animal protein for young children.

10. Budget (US$)				
Outcome/Output/Activity	Sub-activity	Budget Item	WorldVeg	AMEDD
Outcome 2/Output 1/Activity 1	MA2111-17	Personnel	10,000	1,000
		Services	5,500	1,000
		Supplies	3,500	1,000
		Equipment		
		Travel	7,000	2,000
		Overhead	4,160	800
		Subtotal	30,160	5,800
		Grand Total	**35,960**	

Outcome 4:	Effective partnerships are built with farmers, local communities, and research and development partners in the private and public sectors to ensure delivery and uptake at the scale of SI, technologies, innovations and practices.
a. Output 4.1:	Alliances and effective partnerships developed between farmers, local communities, and research and development agents in the public and private sectors to enable the release, dissemination, and adoption of proven technologies and practices to scale.
b. Activity 4.1.1:	Conduct cost-benefit and gender analysis coupled with other socio-economic analyses to identify and quantify adoption constraints and opportunities for different farmer contexts.
c. Sub-activity MA 4111-18:	Predicting the adoption of sustainable agricultural practices in Sudan and Guinean Savana agro-ecologies.

d. Research team

Name	Institution	Role
Bekele Kotu	IITA	Economic analysis
Francis Muthoni	IITA	GIS analysis
Felix Badolo	ICRISAT	Economic analysis
Abdul Rahman Nurudeen	IITA	Biophysical evaluation

e. Student(s)

Name	Institute	Degree	Start	End

f. Location(s)	Ghana: Northern Region, Upper West Region, and Upper East Region Mali: Koutiala and Bougouni districts
g. Start	July 2018
h. End	December 2019

1. Justification

The farming systems in Northern Ghana and Southern Mali are characterized by low productivity caused by the low use of improved agricultural technologies, low soil fertility, pest attacks, and low and unpredictable rainwater (Ellis-Jones et al., 2013[28], Aniah et al., 2013[29], Ollenburger et al., 2016[30]). The low productivity of crops, particularly the staple ones, has resulted in food insecurity and poverty among farming households (Mahama et al. 2017[31]; Kotu et al., 2017[32]). Several best fit technologies have been identified within Africa RISING including (among others): improved crop varieties, soil fertility improvement/management methods, and crop pest control methods. Studies indicate that

[28] Ellis-Jones J, Larbi A, Hoeschle-Zeledon I, Dugie I Y, Teli I A, Bauh S S J, Kanton R A L, Kombiok J M, Kamara A Y, and Gyamfi I (2013). Sustainable intensification of cereal-based farming systems in Ghana's Guinea savannah: Constraints and opportunities identified with local communities. IITA Report. IITA, Ibadan, Nigeria

[29] Aniah, P., Wedam, E., Pukunyiem, M., & Yinimi, G. (2013). Erosion and livelihood change in North East Ghana: A look into the bowl. International Journal of Sciences: Basic and Applied Research, 7(1), 28–35

[30] Ollenburger, M. H., Descheemaeker, K., Crane, T.A., Sanogo, O.M., Giller, K. E., 2016. Waking the sleeping giant: Agricultural intensification, extensification or stagnation in Mali's Guinea Savannah. Agricultural Systems 148 (2016) 58–70.

[31] Mahama S, Oladele J, Larbi A, Hoeschle-Zeledon I. 2017. Household food insecurity, coping strategies, and nutritional status of pregnant women in rural areas of Northern Ghana. Food Sci Nutr. http://doi.org/10.1002/fsn3.506

[32] Kotu, B. H., Alene, A., Manyong, V., Hoeschle-Zeledon, I., & Larbi, A. (2017) Adoption and impacts of sustainable intensification practices in Ghana. International Journal of Agricultural Sustainability, 15 (5), 539-554, DOI: 10.1080/14735903.2017.1369619

some newly developed farming technologies and techniques are superior to existing practices and, if adopted, will improve the livelihood of smallholder farmers (Abdulai et al., 2017[33], Michalscheck et al., 2017[34]; Buah et al., 2013[35]; Kanton et al., 2013[36]). Farmers have also started using some of the technologies promoted in their areas. However, there has been little effort to predict the adoption and diffusion of the new technologies among the smallholder farmers in the areas where they have experimented and beyond. Prediction of the adoption of the technologies will be useful for improved evaluation of potential investments in agricultural research, development and extension (Alston et al., 1995[37]) or policy adjustments (Pannell et al., 2006[38]) that depend crucially on assumptions about rates of adoption of new practices. Therefore, this study will assess the potential adoption rate and the time needed to reach that level by considering the characteristics of the technologies and the smallholder farmers' population.

2. Objectives

2.1 To predict the adoption of sustainable intensification technologies promoted by Africa RISING project in Northern Ghana and Southern Mali

2.2 Identify and display potential locations for scaling of the technologies

3. Research questions

3.1 How much is the peak and speed of adoption for various technologies promoted by Africa RISING project in Northern Ghana and Southern Mali

3.2 What are the most important factors determining the peak and speed of adoption among various technologies?

4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)

We will consider multiple practices such as cropping system diversification (spatial as well as temporal), soil fertility management practices, improved varieties, and other best bit technologies to be identified. Data will be collected from secondary sources (such as previous surveys and literature) and primary sources. For primary data, we will conduct focus group discussions and key informant interviews. Data will be collected on key variables on four major drivers of adoption: 1) relative advantage for the population; 2) relative advantage of the practice; 3) learnability characteristics of the practice; 4) population-specific influences on the ability to learn about the practice. The Adoption and Diffusion

[33] Abudulai, M., Kusi, F., Seini, S. S., Seidu, A., Nboyine, J. A., Larbi, A. 2017. Effect of planting date, cultivar and insecticide spray application for the management of insect pests of cowpea in northern Ghana. Crop Protection, 100:168-176.

[34] Michalscheck M., Groot J.C.J., Kotu B., Hoeschle-Zeledon I., Kuivanen K., Descheemaeker K., Tittonell P. (2017). Model results versus farmer realities: Operationalizing diversity within and among smallholder farm systems for a nuanced impact assessment of technology packages. Agricultural Systems 162: 164–178

[35] Buah S J, Larbi A and I. Hoeschle-Zeledon (2013) Grain yield responses of maize to nitrogen fertilizer rate in the Guinea savannah. Paper presented at the ' 6th International Nitrogen Conference', Kampala, Uganda, 18-22 November, 2013.

[36] Kanton R A L, Larbi, A., Buah, S. S., Kombiok, J. M., Ansoba, E., Aungre, P.A. Asungre, Lamin, S., Prasad, P.V. V. (2013). Effect of nitrogen fertilizer on growth and yield of maize varieties with different maturities in a dry agro-ecology of northern Ghana. Accepted for presentation at the Annual General Meeting of the Crop Science Society of America (CSSA)/ Soil Science Society of America (SSSA) and the American Society of Agronomy (ASA), Tampa, Florida, 3 – 7th November 2013.

[37] Alston, J., Norton, G., Pardey, P., 1995. Science under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting. Cornell University Press, Ithaca, NY.

[38] Pannell, D., Marshall, G., Barr, N., Curtis, A., Vanclay, F., Wilkinson, R., 2006. Understanding and promoting adoption of conservation technologies by rural landholders. Australian Journal of Experimental Agriculture, 46, 1407–1424.

Outcome Prediction Tool (ADOPT) will be used for predicting adoption (Kuehne et al., 2017[39]). GIS will be used to identify and display areas of potential scaling.				
5. Data to be collected and uploaded				Responsibility/Institute
The dataset will be uploaded to the repository of the program (Dataverse)				IITA
6. Milestones				
Deliverables		Means of verification		Date
6.1 Dataset		Dataverse		Jun. 2019
6.2 Technical report		Report submitted to IITA		Sep. 2019
6.3 Journal article		Article submitted to journal		Sep. 2019
7. Sustainable intensification indicators				
7.1 Productivity		Yield (grain, biomass)		
7.2 Environmental		Environmental impact, time to environmental impact		
7.3 Economic		Profit in the year that it is used, profit in future time, time of profit to be realized		
7.4 Social		Group involvement		
7.5 Human		Ease and convenience, practice awareness, relevant existing skill and knowledge		
8. How is the activity in this protocol linked to those of others?				
This research takes the outputs of previous bio-physical studies as input.				
9. How are the activities in this protocol linked to those of others?				
10. Budget (US$)				
Outcome/Output /Activity	Sub-activity	Budget Line	ICRISAT	IITA
Outcome 4/Output 1/Activity 1	MA4111-18	Personnel	5,000	
		Services	1,000	1,500
		Supplies	1,000	1,500
		Capital		
		Travel	5,000	5,000
		Overhead (16%)	1,920	
		Subtotal	13,920	8,000
		Grand Total	**21,920**	

[39] Kuehne, G., Llewellyn, R., Pannell, D.J., Wilkinson, R., Dolling, P., Ouzman, J., Ewing, M. 2017. Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy Agricultural Systems 156 (2017) 115–125

Outcome 4:	Effective partnerships to ensure delivery and large-scale uptake of SI technologies and practices are established with farmers, local communities, and research and development partners in the private and public sectors.			
Output 4.3:	An updated framework for monitoring technology adoption to be used by the project team and scaling partners available and accessible			
Activity 4.3.2:	Make reports available on the Africa RISING repositories.			
Sub-activity MA4321-18:	GIS mapping of implemented technologies across different agro-ecologies and demographic settings to help evaluation of adoption practices.			
Research team				
Name	Institution	Role		
Bougouna Sogoba	ICRISAT/AMEDD	Activity leader		
Birhanu Zemadim	ICRISAT	Project collaborator		
Oumar Samake	AMEDD	Community mobilization and household socio-economic data collection		
Gilbert Dembele	AMEDD	Remote sensing data collection		
Francis Muthoni	IITA	GIS specialist		
Student(s)				
Name	Institute	Degree	Start	End
1.				
Location(s)	Koutiala and Bougouni			
Start	July 2018			
End	June 2019			
Justification				
Technology adoption by farmers is linked to changes in environmental and climate variations but also to the household socio-economic status and the cultural acceptance of technologies. The reliability and replicability of the technologies depend on the specific context in which the technologies are developed and implemented. Regarding the available technologies developed in phase one of the Africa RISING project and technologies under validation in phase II, it is important to map and characterize using GIS and remote sensing technologies under different agro-ecological and socio-economic context.				
2. Objectives				
2.1 To map and characterize Africa RISING technologies for different agro-ecologies and socio-economic settings in Mali.				
2.2 To analyse the adoption and/or adaptation of the developed technologies in relation to household socio-economic and environmental conditions in Africa RISING intervention villages in Mali.				
3. Research questions				
3.1 To which extent Africa RISING technologies have been adopted under different socio-economic and environmental conditions in Mali.				
3.3 What drives technology adoption in Africa RISING intervention villages?				
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)				
4.1 The protocol will follow remote sensing image (Landsat, sentinel 2) treatments to extract land use and land cover information (classification with random forest classifier) from 2000 to 2018. Vector data (road, market, villages, water site) will be applied to better understand the site context. For each				

technology developed by the project the coordinates of the farmers who participate in the project will be projected on the developed map to analyse deeply the context of adoption. In the different villages, socio-economic data on the households' conditions will be collected and analysed with GIS tools to link environmental status to socio-economic status and the location where the technologies have been adopted or adapted.

5. Data to be collected and uploaded	Responsibility/Institute
5.1. Remote sensing data	AMEDD
5.2 Economic data: household living condition	AMEDD

6. Milestones		
Deliverables	Means of verification	Date
6.1 Freely available land use and land cover maps, changes detection map from Landsat at 30 m resolution	Maps developed and shared separately to be uploaded on Africa RISING wikispace	Dec. 2018
6.2 Scientific article on context domain of technologies in Koutiala and Bougouni districts	Draft publication	Dec. 2019

7. Sustainable intensification indicators	
7.1 Productivity	Area of crops grown per season
7.2 Environmental	Percentages of vegetative and tree cover in different seasons
7.3 Economic	
7.4 Social	Active farmer groups Active innovation platforms Percentages of community members participating in some form of social group
7.5 Human	

8. How will scaling be achieved?
The determination of the analogue sites and the adoption or adaptation condition will help to better orient the scaling up of different technologies developed by Africa RISING

9. How are the activities in this protocol linked to those of others?
This activity is linked to all sub-activities.

10. Budget (US$)				
Outcome/Output/Activity	Sub-activity	Budget Line	IITA	AMEDD
Outcome 4/Output 4/Activity 1	MA4321-18	Personnel		5,000
		Services	1,000	3,000
		Supplies	1,000	2,000
		Capital		
		Travel	5,000	5,000
		Overhead (16%)		2,400
		Subtotal	7,000	17,400
		Grand Total	**24,400**	

Outcome 4:	Effective partnerships to ensure delivery and large-scale uptake of SI technologies and practices are established with farmers, local communities, and research and development partners in the private and public sectors.			
a. Output 4.4:	Knowledge sharing centers and learning alliances within existent local and regional institutions including development actors developed.			
b. Activity 4.4.1:	Establish knowledge-sharing and learning alliances among scaling actors.			
c. Sub-activity MA4411-18:	Operation of four technology parks as hubs for research and dissemination in Bougouni and Koutiala.			
d. Research team				
Name	Institution	Role		
Birhanu Zemadim	ICRISAT	Leader and scientist on land and water		
Bougouni site coordinator	ICRISAT	Activity coordination		
Koutiala site coordinator	ICRISAT	Activity coordination		
John Nzungize	ICRISAT	Scaling best-bet technologies		
Salmoye Coulibaly	ICRISAT	Administrative assistant		
Oumar Samake	AMEDD	Koutiala multi-stakeholder facilitator		
Tumaini Sidibe	FENABE	Bougouni multi-stakeholder facilitator		
e. Student(s)				
Name	Institute	Degree	Start	End
f. Location(s)	Bougouni and Koutiala districts			
g. Start	April 2018			
h. End	March 2021			
1. Justification:				
The Mali Africa RISING project is coordinated by ICRISAT in close collaboration with partner institutes. Four technology parks were established, two in Bougouni (Flola and Diaba villages), and two in Koutiala (M'Pessoba and N'Golonianasso villages). These parks have been used by participating institutes (ICRISAT, ICRAF, WorldVeg and IER) to conduct controlled research experiments. Training programs have been conducted in the parks for local NGOs, national training centers and communities living in the Africa RISING intervention villages. The parks have been used by other programs like the West Africa sorghum improvement program, the sorghum and millet dissemination project (ARDT_SMS), groundnut improvement program for capacity building and outreach activities. In addition, the establishment of the parks has integrated the research and capacity building activities by the different project partners. From phase I of the program it was understood that the long-term sustainability of running innovation platforms was not very likely. In this case, the four technology parks have been utilized to conduct multi-stakeholder interest group meetings and this is to continue in the current year and beyond. Emphasis would be given to engaging more numbers of youth in research and scaling activities. The end goal would be to formalize the four parks as unique community level multi-stakeholder platforms for all programs conducted in the specific village. The activities in the parks will be guided by the local NGOs, AMEDD and FENABI.				
2. Objectives				
2.1. Conducting integrated and multi-disciplinary research and scaling strategy on sustainable intensification program.				
2.2. Developing a research hub for validating Africa RISING technologies for wider dissemination, providing capacity building and short-term training programs.				

2.3. Provide a site for multi-stakeholder interest group meetings.		
2.4. Provide information concerning proven technological practices and climate services to farmers, local NGOs and extension agents.		
2.5. Provide high-quality agricultural inputs (plant material, fertilizer etc.), and climate-smart water access facilities to farmers.		
3. Research questions		
3.1. None		
4. Procedures (survey methods, gender disaggregation, treatments, experimental design, sample size, etc.)		
The four technology parks will be utilized by the research team for various research and dissemination strategies. At each site, scientists and implementing partner institutes will identify and determine the size of the field plot to implement the field trials. Training programs will be provided to participating farmer groups (particularly the youth and women groups) on the introduced technology prior to activity implementation. With the use of these technology parks and independently identified farmers' fields, and according to the phase II proposal we are expecting to reach 2,514 households through research and capacity building activities in the year 2018/2019. Identified best-bet technologies would be scaled to approximately 11,752 households through development actors who are working with Africa RISING program. The socio-economy group will monitor the adoption of identified technologies in farmers' fields and conduct continuous monitoring and evaluation of the five sustainable intensification domains. In each technology park, a farmer field day will be organized to bring the various groups of farmers (adult, youth, women etc.) together and create an opportunity to discuss the types of technologies introduced, the relevance and challenges among the farmer groups. Approximately 300 farmers are expected in each of the farmer field days and one-third of the invitees will be youth farmers.		
5. Data to be collected and uploaded		Responsibility/Institute
5.1 All field trial data that include agronomic, land, soil and water management		ICRISAT
5.2 All data related to training and farmers field visit		ICRISAT
6. Milestones		
Deliverables	Means of verification	Date
6.1 Biophysical database on improved technological practices and participatory research in the technology parks.	Implemented trials, metadata and database uploaded on Dataverse	Mar. 2019
6.2 Types of technologies disseminated, capacity building, farmers' field visit and video demonstration.	Interim and final reports to IITA	Mar. 2019
7. Sustainable intensification indicators		
7.1 Productivity	N/A	
7.2 Environmental	N/A	
7.3 Economic	N/A	
7.4 Social	N/A	
7.5 Human	N/A	
8. How will scaling be achieved?		
The technology parks are the sites for technological innovation, demonstration and capacity building. Best-bet technological innovations will be scaled-up to farmers fields through farmers exchange visits		

and implementation of trials at farmers field. Hence technology parks are considered as ideal sites where scaling works start.
9. How are the activities in this protocol linked to those of others?
The proposed crop-livestock activities in the current work plan were previously implemented in the technology parks and will be implemented in the same technology parks.

10. Budget (US$)					
Outcome/Output/Activity	Sub-activity	Budget Line	ICRISAT	AMEDD	FENABE
Outcome 4/Output 4/Activity 1	MA4411-18	Personnel	30,000	3,500	3,500
		Services	5,500	4,000	4,000
		Supplies	3,500	2,000	2,000
		Capital			
		Travel	3,500	2,500	2,500
		Overhead (16%)	6,800	1,920	1,920
		Subtotal	49,300	13,920	13,920
		Grand Total	**77,140**		

Consolidated budget

Outcome	Output	Activity	Subactivity	ICRISAT	ILRI	WorldVeg	IITA	IER	WUR	AMEDD	FENABE	Budget per Activity/Output/ Outcome
1	1	1	MA1111-18	27,956						5,220		33,176
			MA1112-18	34,800						5,220		40,020
			MA1113-18	28,959								28,959
			MA1114-18	15,080		25,056	8,000					48,136
		2	MA1121-18		87,000							87,000
			MA1122-18		37,120							37,120
		3	MA1131-18						20,010			20,010
	2	1	MA1211-18	88,160								88,160
			MA1212-18					15,728				15,728
2	1	1	MA2111-18			30,160				5,800		35,960
4	1	1	MA4111-18	13,920			8,000					21,920
4	3	2	MA4321-18				7,000			17,400		24,400
	4	1	MA4411-18	49,300						13,920	13,920	77,140
Allocation for graduate students												12,450
Total Budget				**258,175**	**124,120**	**55,216**	**23,000**	**15,728**	**20,010**	**47,560**	**13,920**	**570,180**